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(54) **SYSTEM AND METHOD FOR RANDOMLY ACCESSING COMPRESSED DATA FROM MEMORY**

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(52) **U.S. Cl.**
CPC ***H04N 19/423*** (2014.11)

(58) **Field of Classification Search**
CPC H04N 19/423; H04N 19/70
USPC 375/240.2; 382/232, 233
See application file for complete search history.

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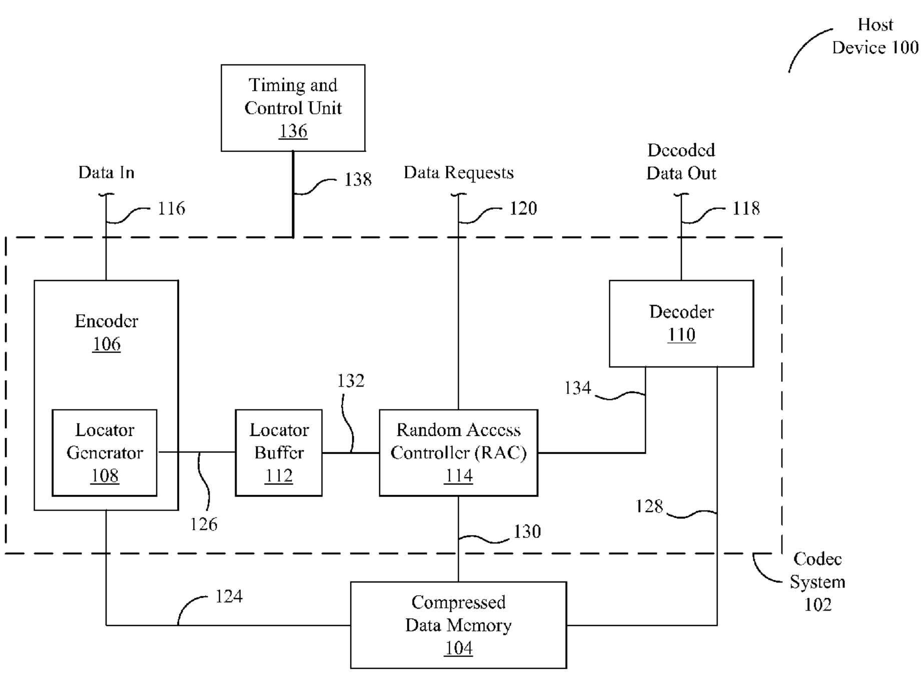
(57) **ABSTRACT**

A method facilitating random access to segments of compressed data stored in memory includes the steps of receiving a series of data segments, encoding the series of data segments into a series of compressed data segments of variable segment sizes, storing the series of compressed data segments in a memory, and generating a locator for each of the compressed data segments. Each locator is indicative of the location of an associated compressed data segment in the memory. A method for randomly accessing a segment of compressed data includes receiving a request for a compressed data segment, retrieving a locator associated with the requested segment, using the retrieved locator to locate the requested segment in the memory, and retrieving the requested segment from the memory. Thus, compressed data segments can be decoded in a different order than the order they were encoded in. Systems for implementing the methods are also disclosed.

39 Claims, 13 Drawing Sheets



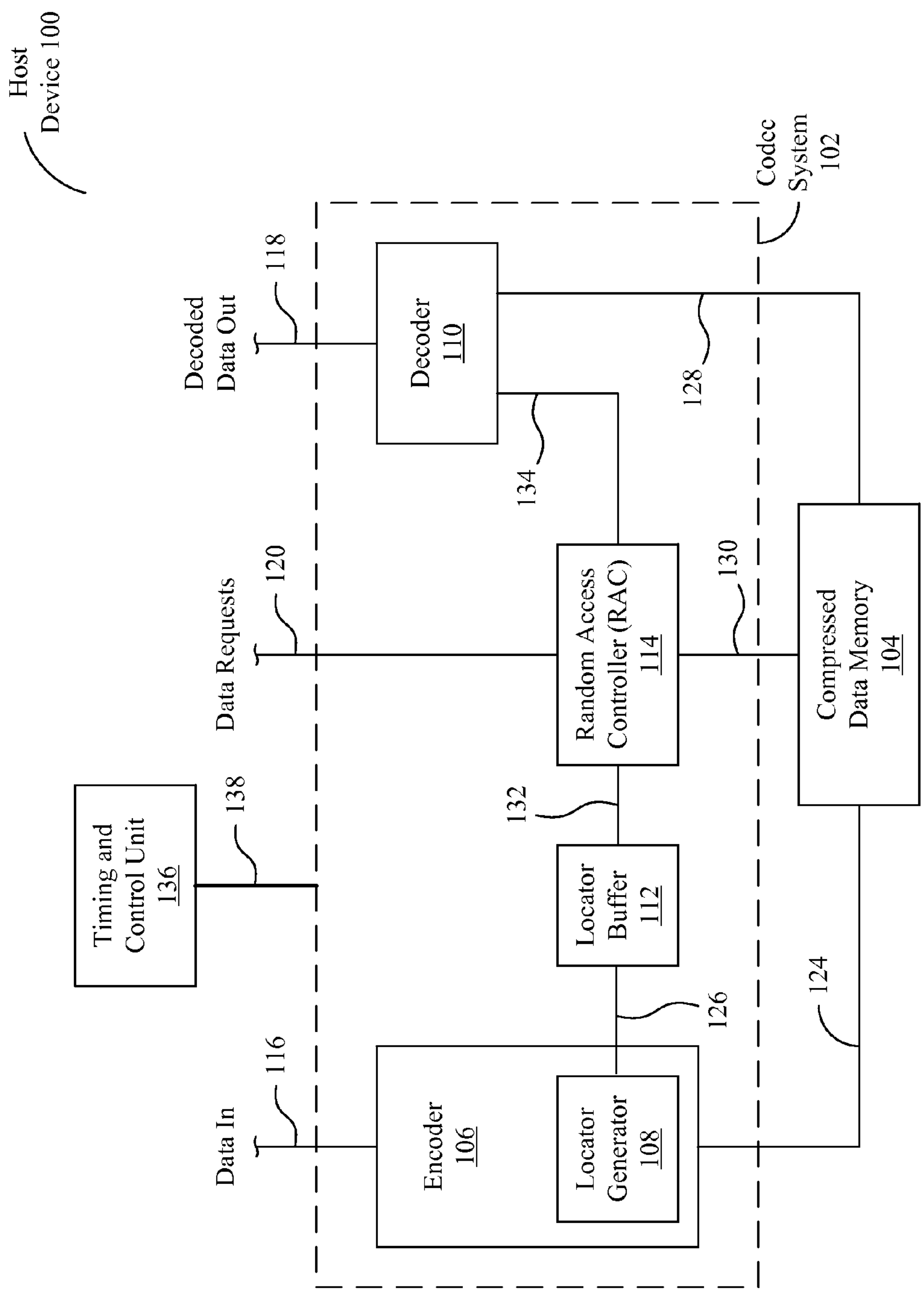

Host Device 100
Codec System 102
Decoded Data Out
118
Decoder 110
128
134
Data Requests
120
Random Access Controller (RAC) 114
130
Compressed Data Memory 104
132
Timing and Control Unit 136
138
Locator Buffer 112
126
124
Data In
116
Encoder 106
Locator Generator 108

FIG. 1

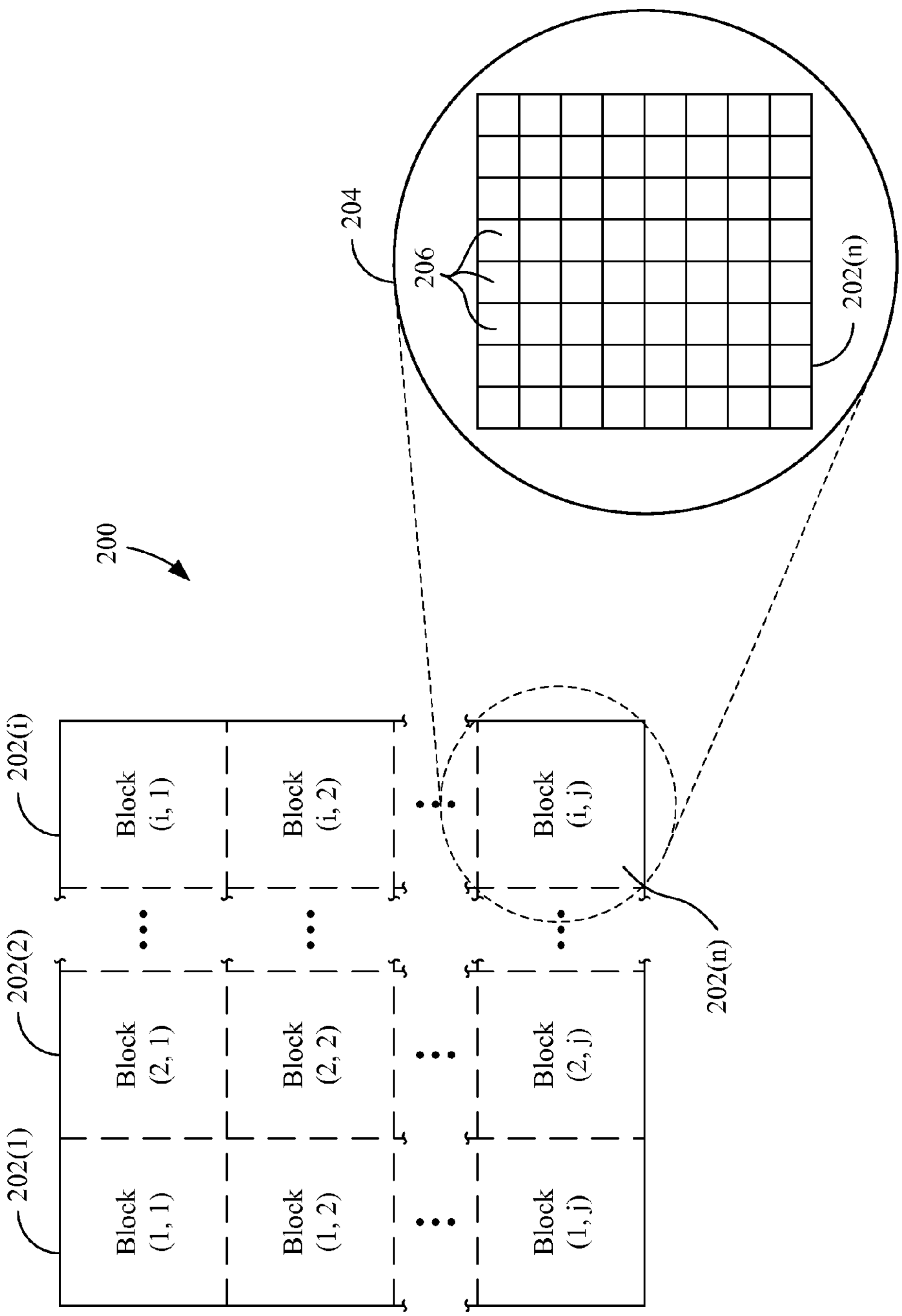

200
202(1)
202(2)
202(i)
Block (1, 1)
Block (1, 2)
Block (1, j)
Block (2, 1)
Block (2, 2)
Block (2, j)
Block (i, 1)
Block (i, 2)
Block (i, j)
202(n)
204
206
202(n)

FIG. 2

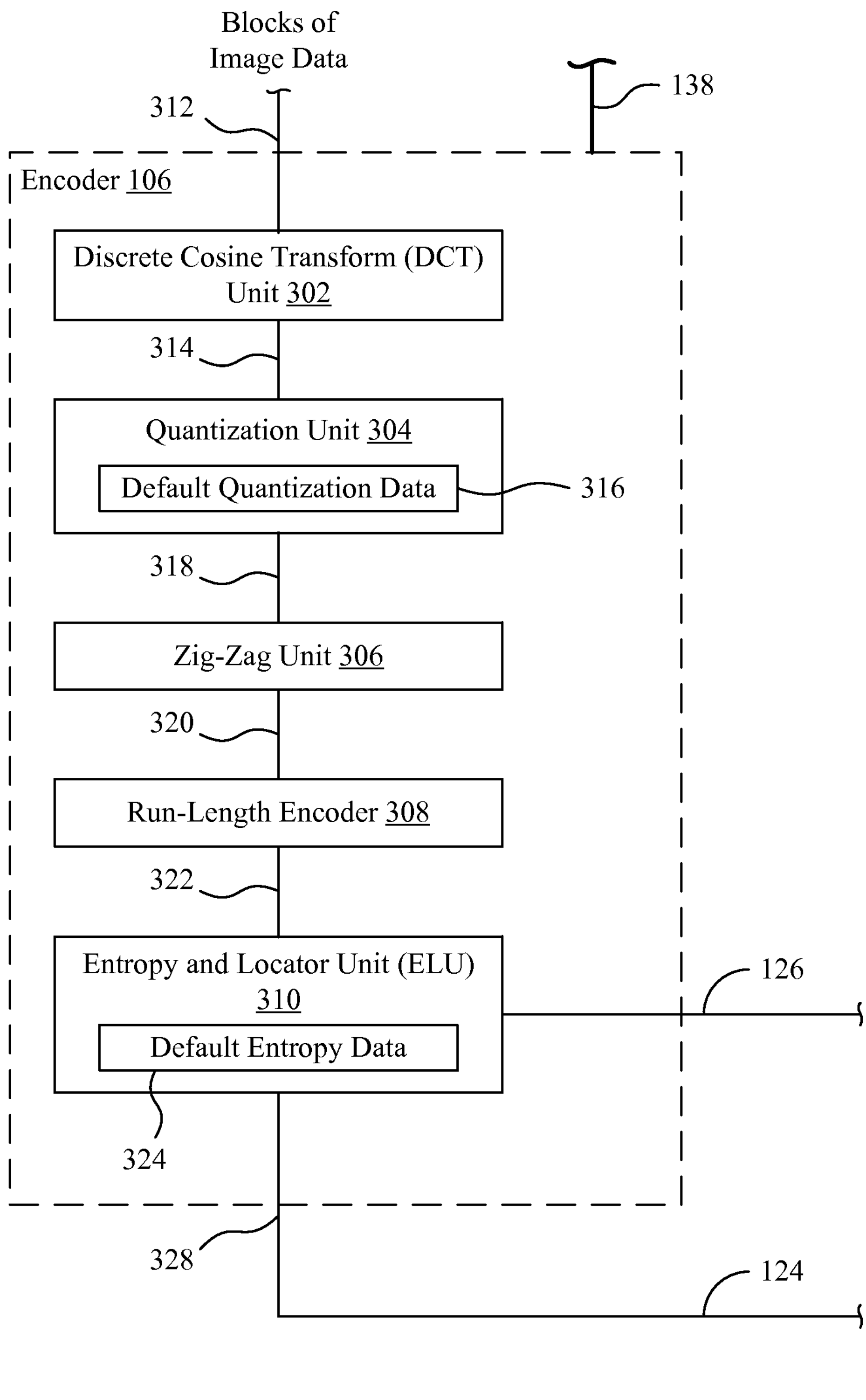
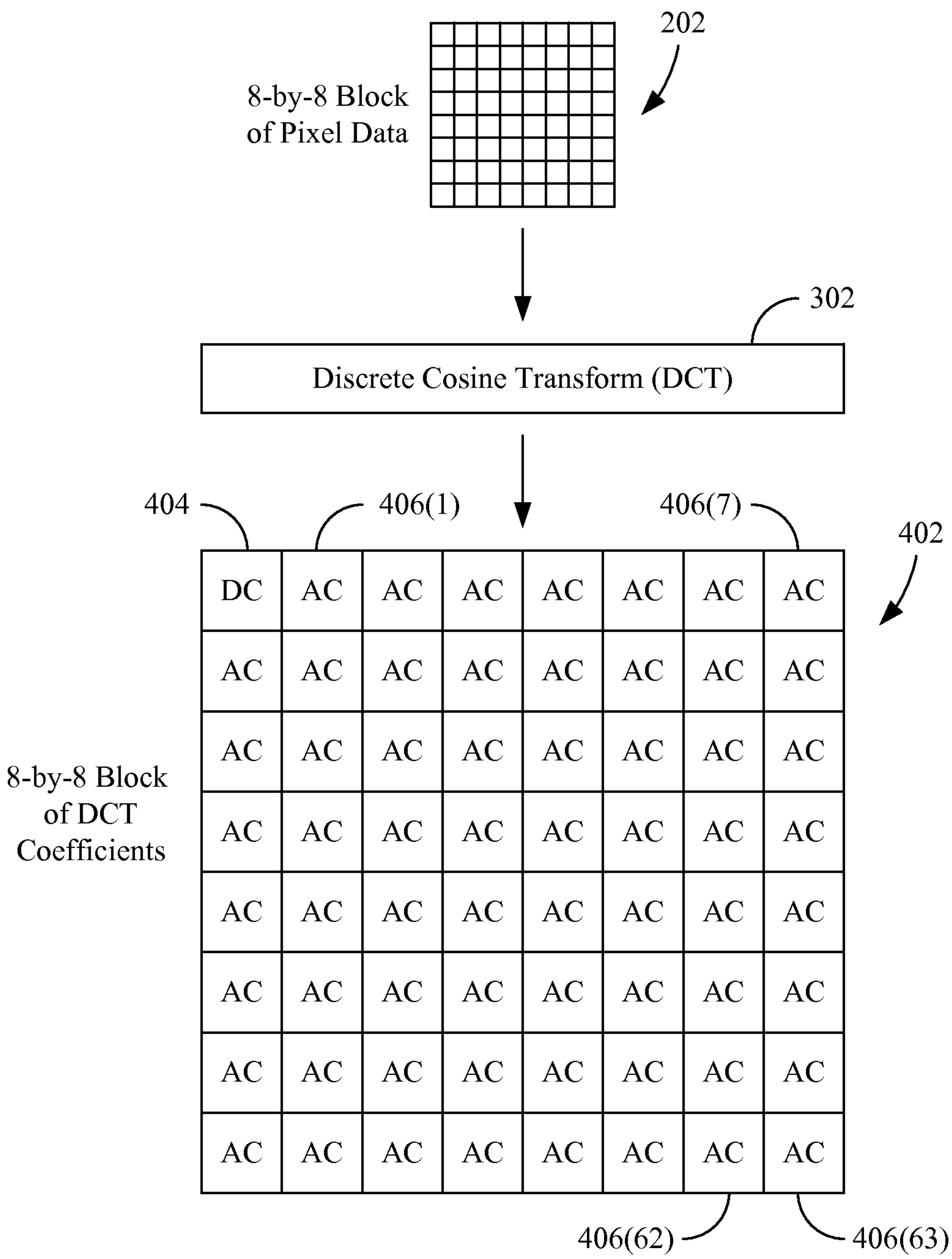

Blocks of
Image Data
312
138
Encoder 106
Discrete Cosine Transform (DCT)
Unit 302
314
Quantization Unit 304
Default Quantization Data
316
318
Zig-Zag Unit 306
320
Run-Length Encoder 308
322
Entropy and Locator Unit (ELU)
310
Default Entropy Data
126
324
328
124

FIG. 3



8-by-8 Block of Pixel Data
202
302
Discrete Cosine Transform (DCT)
404
406(1)
406(7)
402
DC AC AC AC AC AC AC AC
AC AC AC AC AC AC AC AC
AC AC AC AC AC AC AC AC
AC AC AC AC AC AC AC AC
AC AC AC AC AC AC AC AC
AC AC AC AC AC AC AC AC
AC AC AC AC AC AC AC AC
AC AC AC AC AC AC AC AC
8-by-8 Block of DCT Coefficients
406(62)
406(63)

FIG. 4

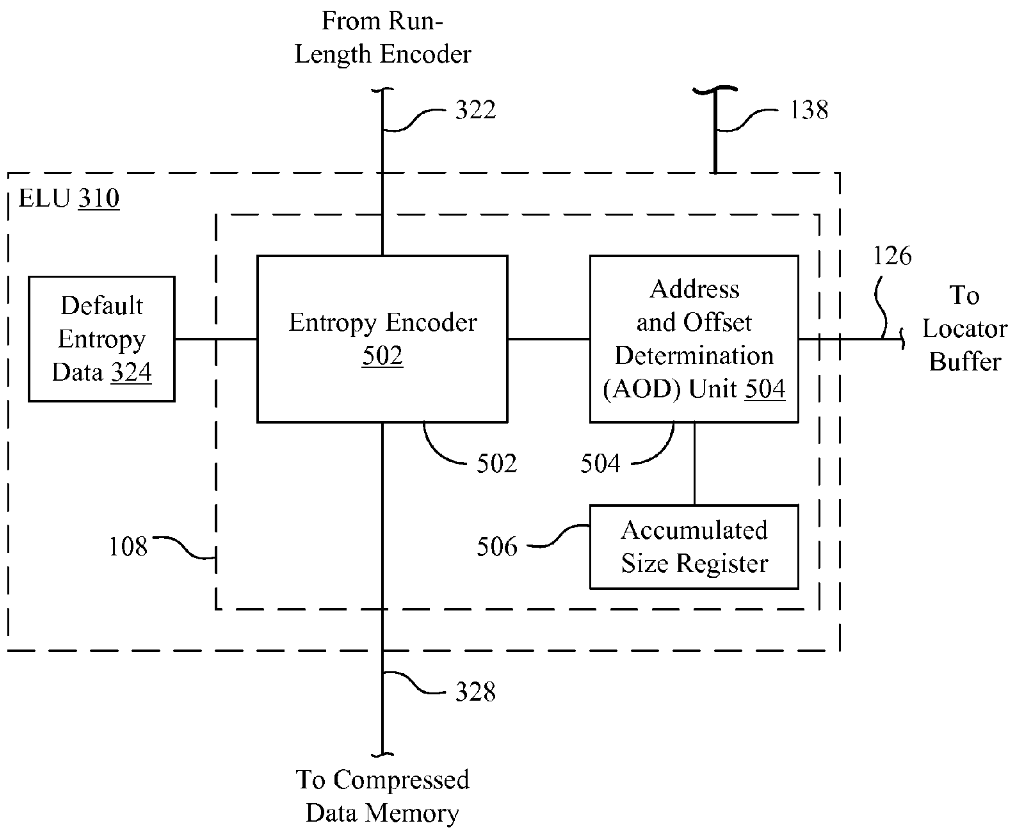

From Run-
Length Encoder
322
138
ELU 310
126
Default
Entropy
Data 324
Entropy Encoder
502
Address
and Offset
Determination
(AOD) Unit 504
To
Locator
Buffer
502
504
108
506
Accumulated
Size Register
328
To Compressed
Data Memory

FIG. 5

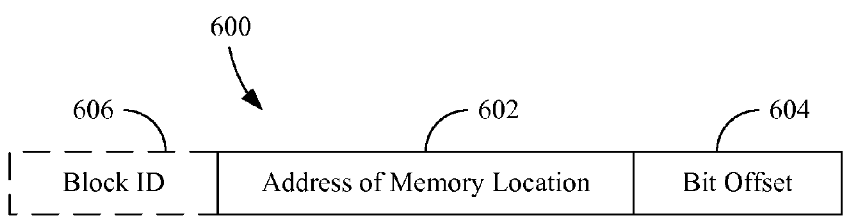

600
606
602
604
Block ID
Address of Memory Location
Bit Offset

FIG. 6

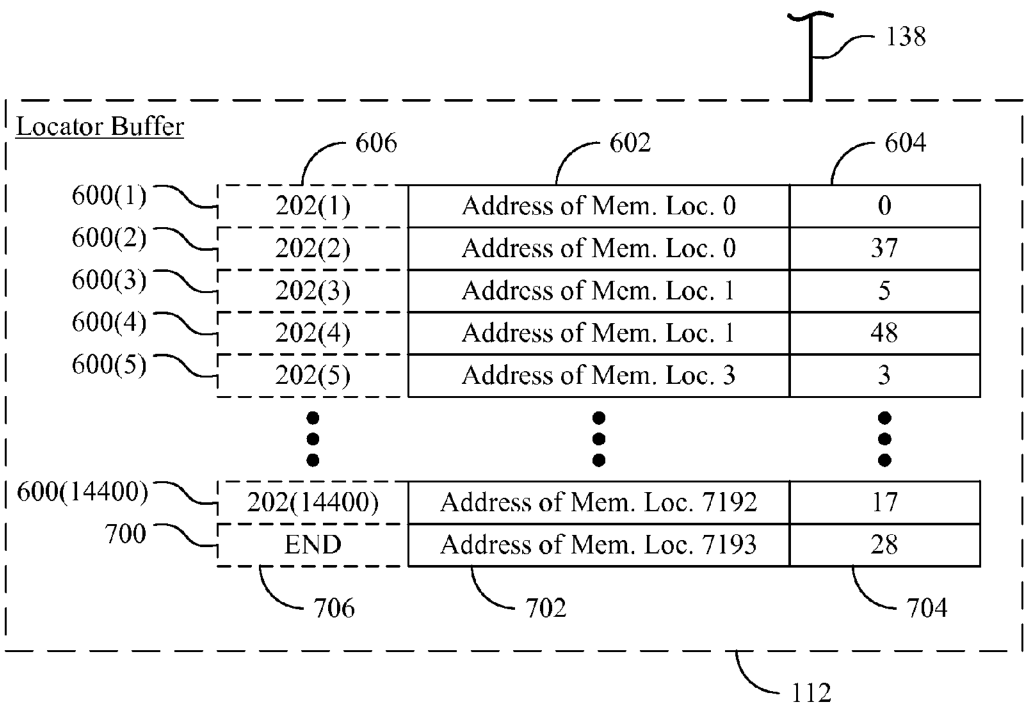

138
Locator Buffer
606
602
604
600(1)
202(1)
Address of Mem. Loc. 0
0
600(2)
202(2)
Address of Mem. Loc. 0
37
600(3)
202(3)
Address of Mem. Loc. 1
5
600(4)
202(4)
Address of Mem. Loc. 1
48
600(5)
202(5)
Address of Mem. Loc. 3
3
600(14400)
202(14400)
Address of Mem. Loc. 7192
17
700
END
Address of Mem. Loc. 7193
28
706
702
704
112

FIG. 7

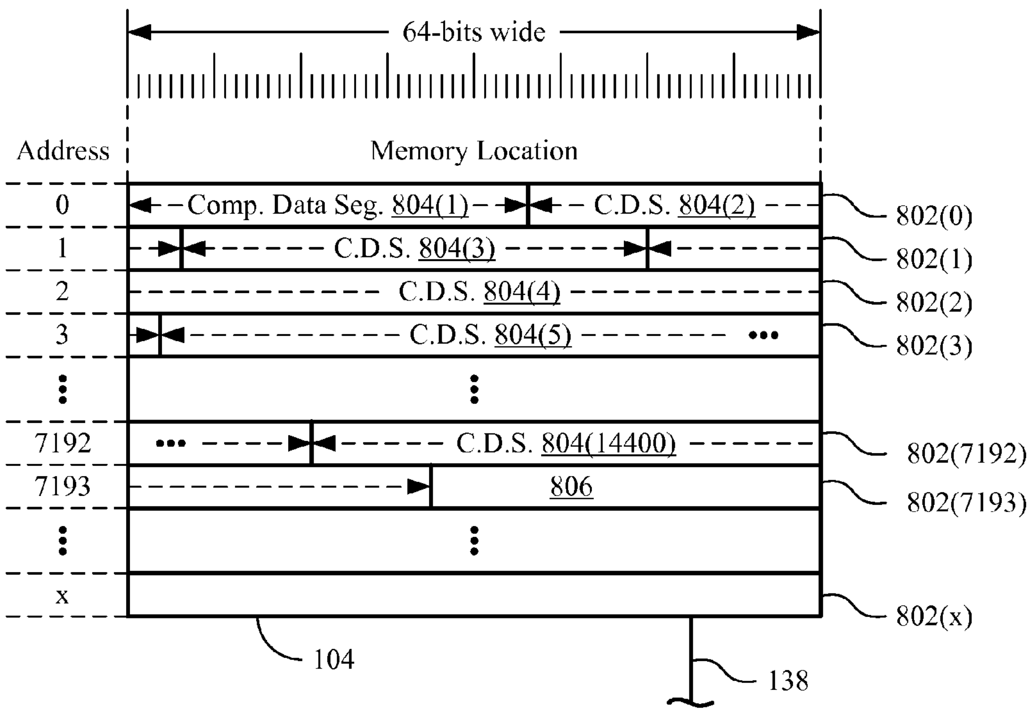

64-bits wide
Address
Memory Location
0
1
2
3
7192
7193
x
Comp. Data Seg. 804(1)
C.D.S. 804(2)
C.D.S. 804(3)
C.D.S. 804(4)
C.D.S. 804(5)
C.D.S. 804(14400)
806
802(0)
802(1)
802(2)
802(3)
802(7192)
802(7193)
802(x)
104
138

FIG. 8

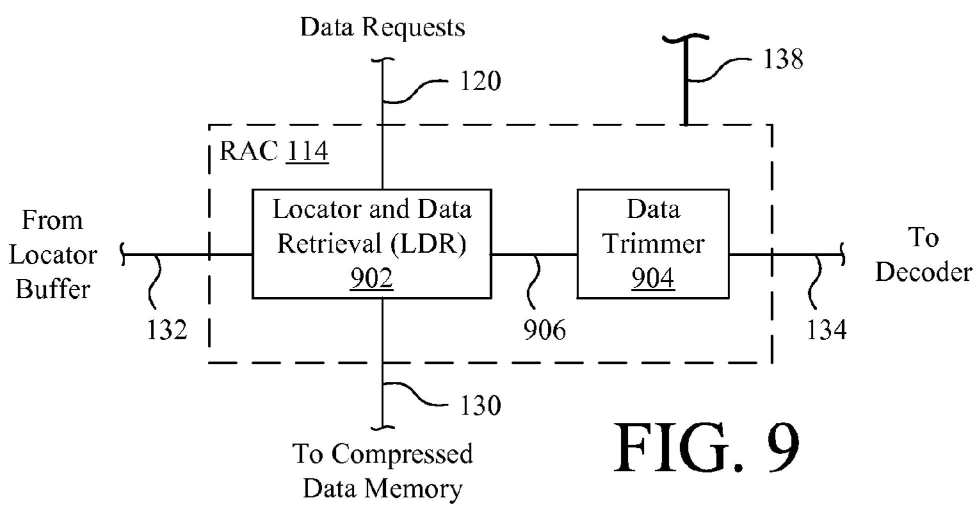

Data Requests
120
138
RAC 114
From Locator Buffer
Locator and Data Retrieval (LDR) 902
Data Trimmer 904
To Decoder
132
906
134
130
To Compressed Data Memory

FIG. 9

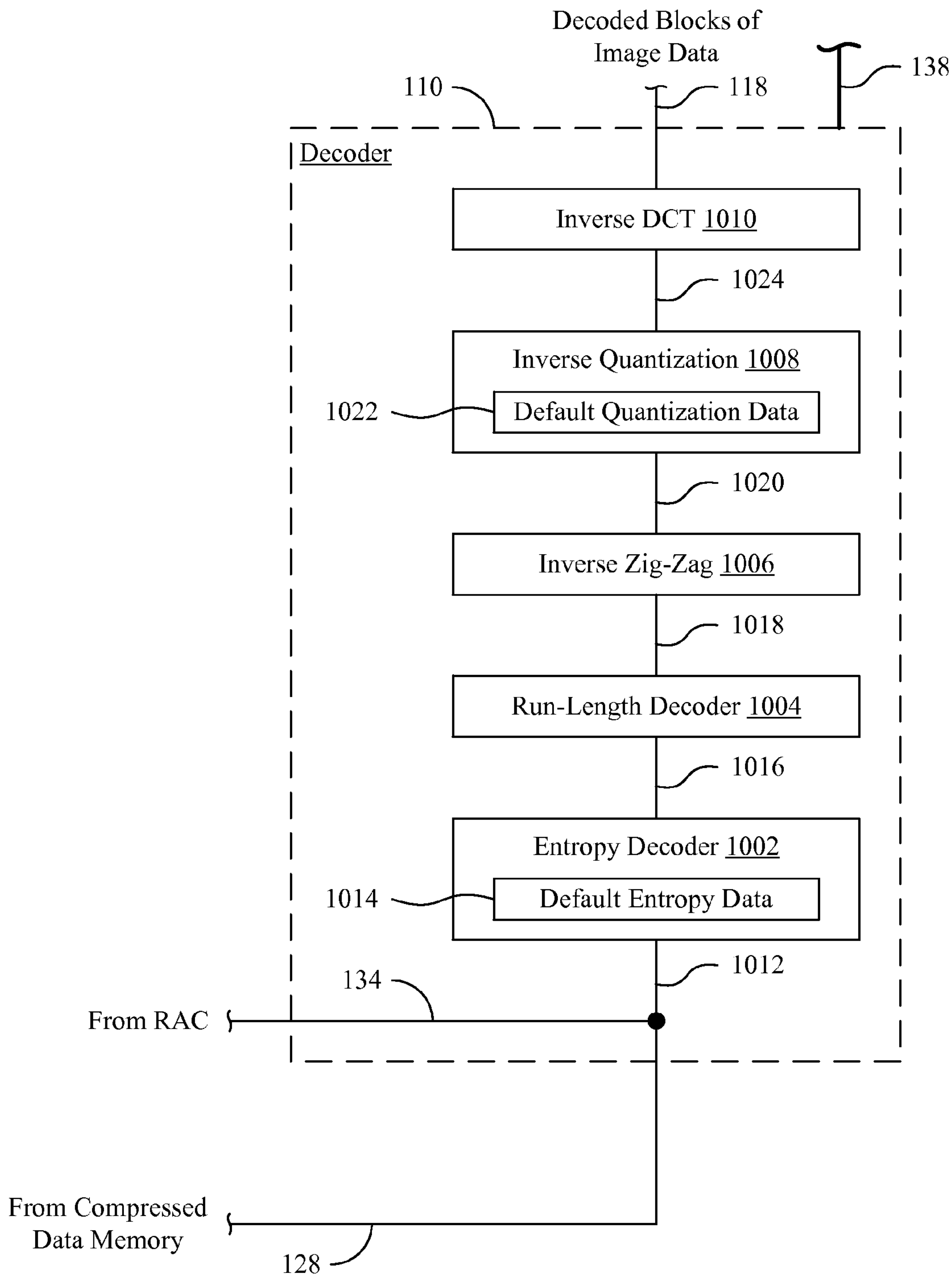

Decoded Blocks of Image Data
138
110
118
Decoder
Inverse DCT 1010
1024
Inverse Quantization 1008
1022
Default Quantization Data
1020
Inverse Zig-Zag 1006
1018
Run-Length Decoder 1004
1016
Entropy Decoder 1002
1014
Default Entropy Data
1012
134
From RAC
From Compressed Data Memory
128

FIG. 10

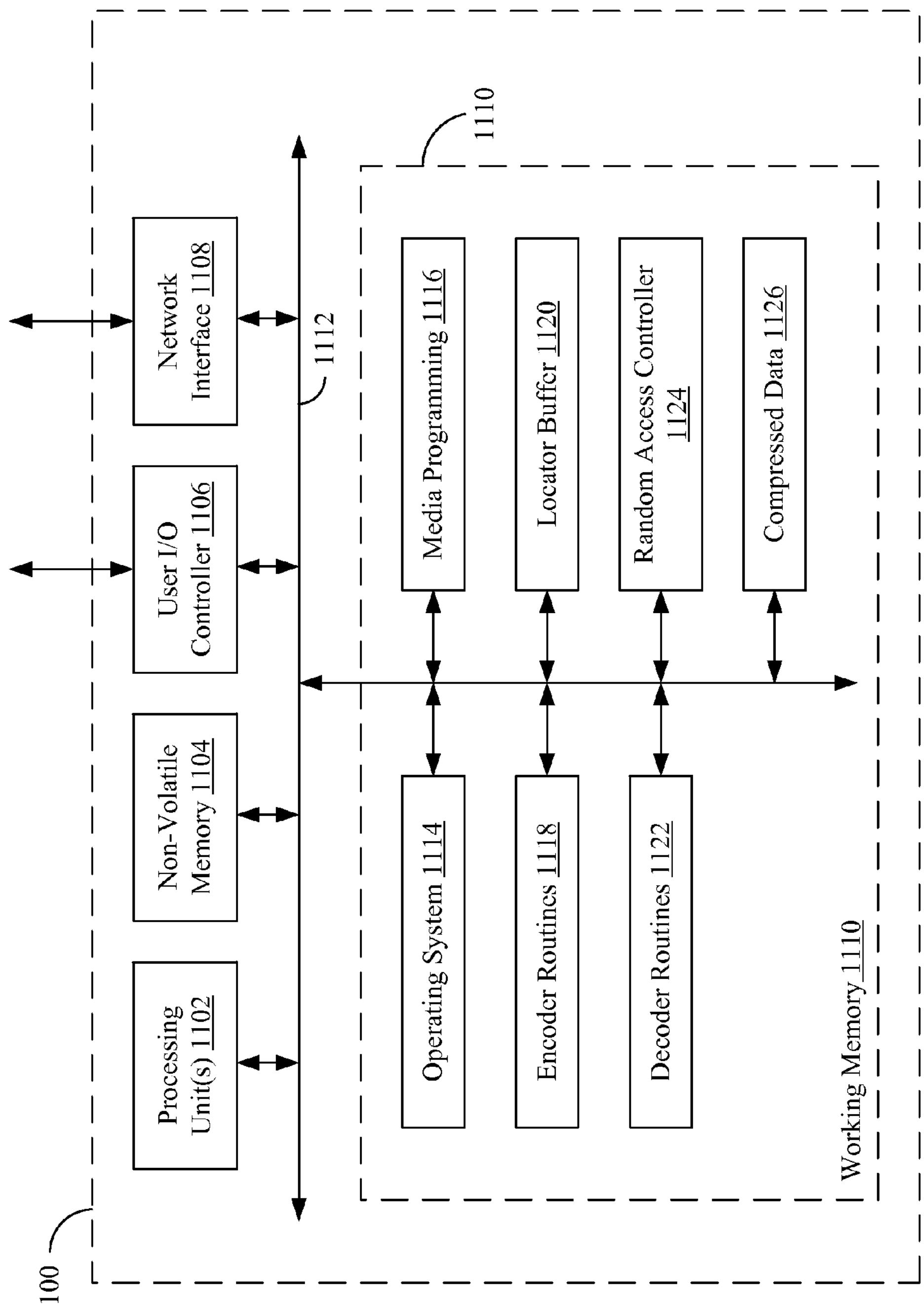

1100
Processing Unit(s) 1102
Non-Volatile Memory 1104
User I/O Controller 1106
Network Interface 1108
1112
1110
Operating System 1114
Media Programming 1116
Encoder Routines 1118
Locator Buffer 1120
Decoder Routines 1122
Random Access Controller 1124
Compressed Data 1126
Working Memory 1110

FIG. 11

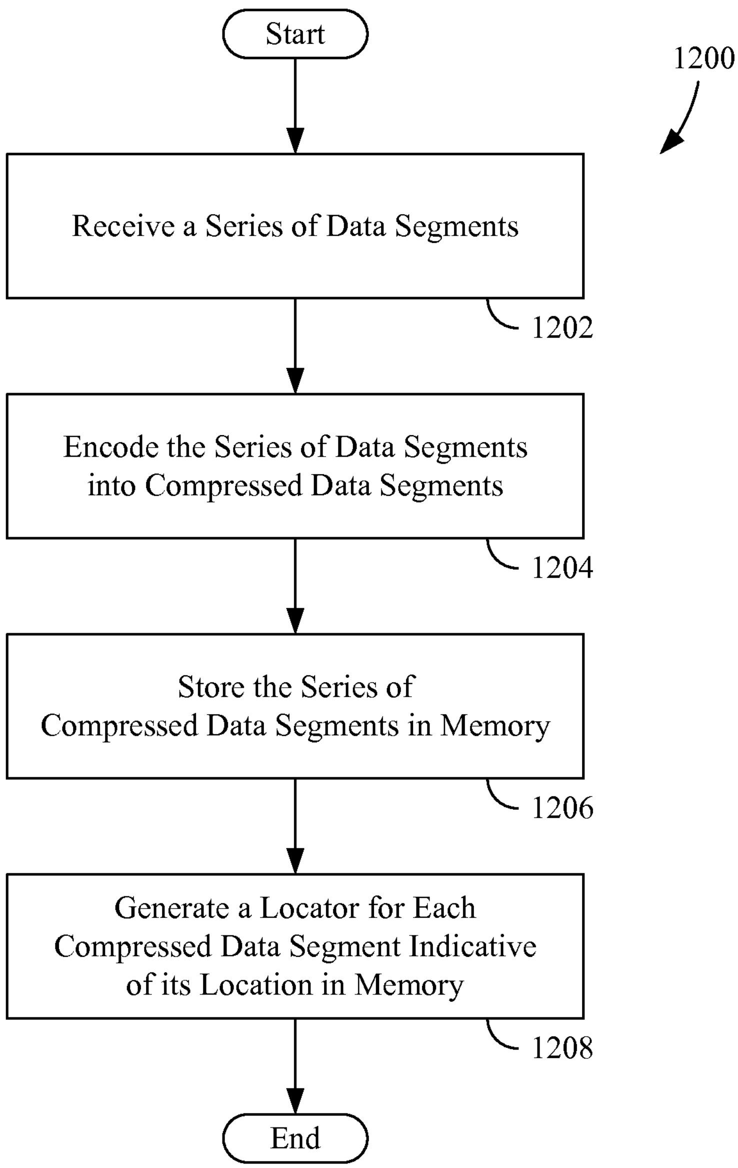

Start
1200
Receive a Series of Data Segments
1202
Encode the Series of Data Segments into Compressed Data Segments
1204
Store the Series of Compressed Data Segments in Memory
1206
Generate a Locator for Each Compressed Data Segment Indicative of its Location in Memory
1208
End

FIG. 12

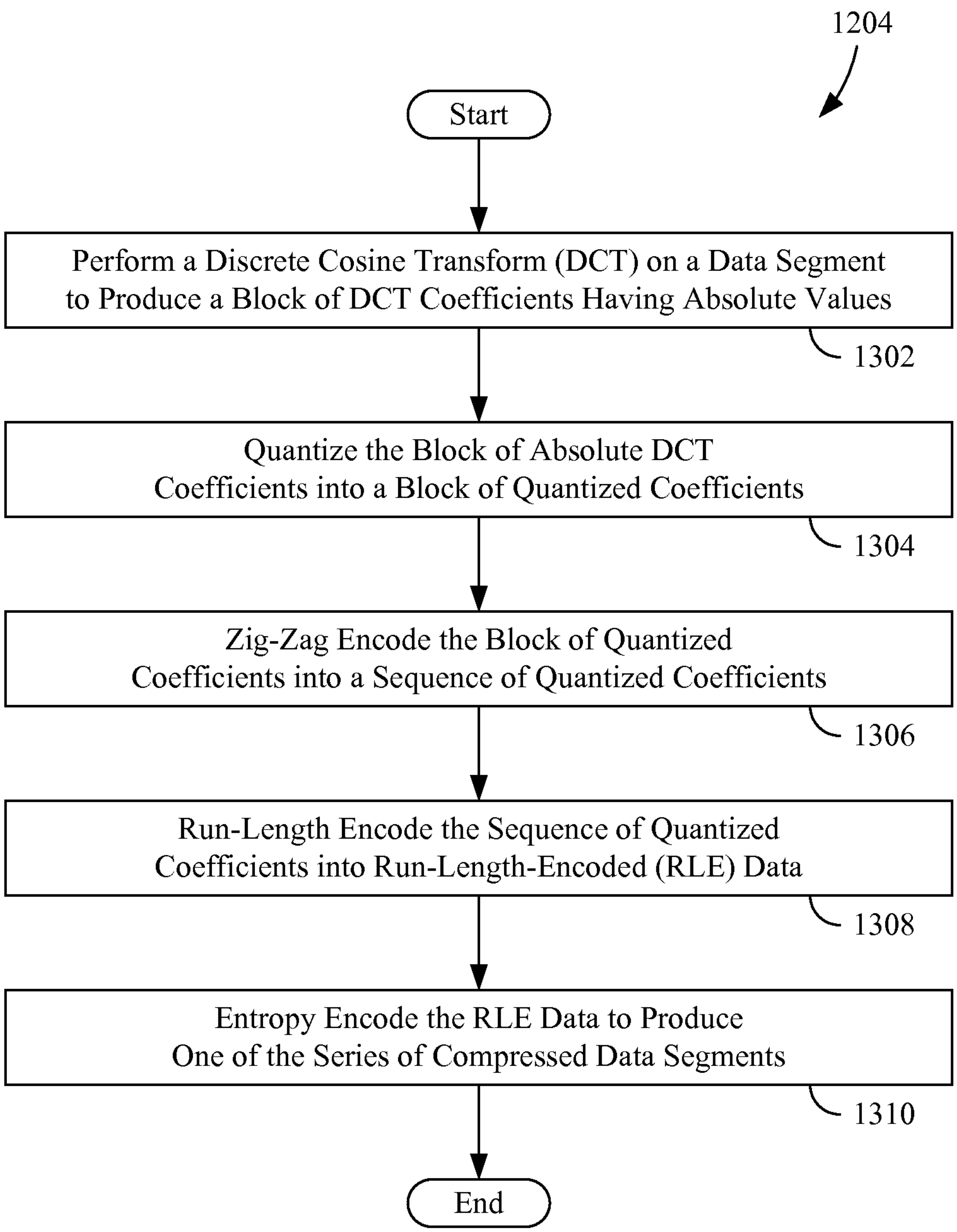

1204
Start
Perform a Discrete Cosine Transform (DCT) on a Data Segment to Produce a Block of DCT Coefficients Having Absolute Values
1302
Quantize the Block of Absolute DCT Coefficients into a Block of Quantized Coefficients
1304
Zig-Zag Encode the Block of Quantized Coefficients into a Sequence of Quantized Coefficients
1306
Run-Length Encode the Sequence of Quantized Coefficients into Run-Length-Encoded (RLE) Data
1308
Entropy Encode the RLE Data to Produce One of the Series of Compressed Data Segments
1310
End

FIG. 13

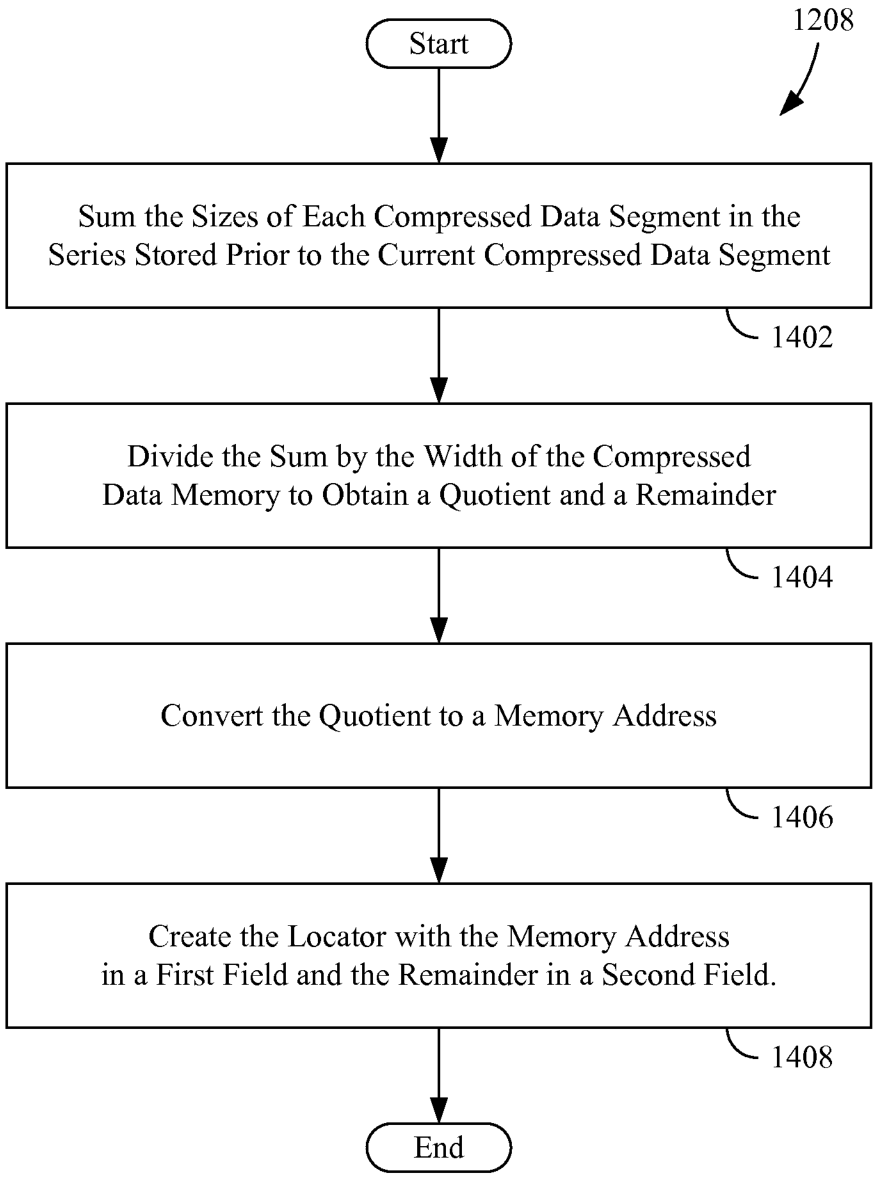

1208
Start
Sum the Sizes of Each Compressed Data Segment in the Series Stored Prior to the Current Compressed Data Segment
1402
Divide the Sum by the Width of the Compressed Data Memory to Obtain a Quotient and a Remainder
1404
Convert the Quotient to a Memory Address
1406
Create the Locator with the Memory Address in a First Field and the Remainder in a Second Field.
1408
End

FIG. 14

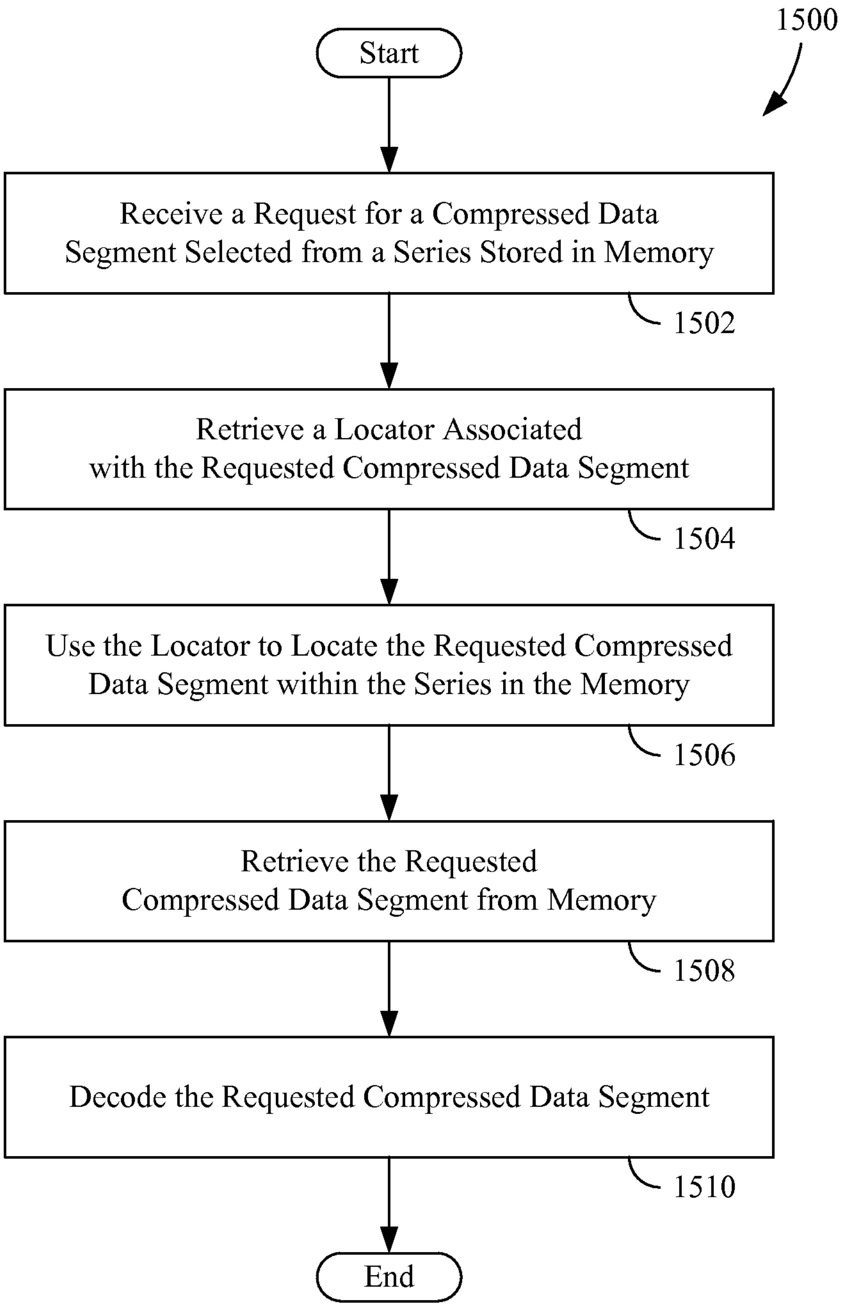

1500
Start
Receive a Request for a Compressed Data Segment Selected from a Series Stored in Memory
1502
Retrieve a Locator Associated with the Requested Compressed Data Segment
1504
Use the Locator to Locate the Requested Compressed Data Segment within the Series in the Memory
1506
Retrieve the Requested Compressed Data Segment from Memory
1508
Decode the Requested Compressed Data Segment
1510
End

FIG. 15

SYSTEM AND METHOD FOR RANDOMLY ACCESSING COMPRESSED DATA FROM MEMORY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to an encoder and decoder system ("codec") for compressing and decompressing data, and more particularly to a codec system that facilitates decoding segments of the compressed data independently and out of the order in which those segments were encoded.

2. Description of the Background Art

Demand for media (e.g., video, still images, etc.), especially high-definition (HD) media, has increased dramatically in recent years. Unfortunately, raw HD media contains very large amounts of data, which makes storing the raw data difficult. For example, storing a frame of raw HD video data requires a very large frame buffer. This is problematic when HD device developers are under pressure to reduce device sizes and costs.

Codecs are used to increase data compression in media devices. In a codec, the encoder receives the raw media data and encodes it into compressed data, which can be stored in memory for later retrieval. When the compressed data is retrieved from memory, it is sent to a decoder, which decodes the compressed data and outputs decoded media data for playback.

Codecs, however, introduce problems of their own. For example, popular image codecs (e.g., JPEG codecs, etc.) introduce data dependencies into the compressed data. As a result, the compressed data defining an image must be decoded in the same order in which it was encoded (i.e., in a first-in-first-out manner). This has the effect that a portion of the decoded image cannot be decoded and accessed without decoding the compressed data that was encoded before it. Codecs also suffer the disadvantage that they require detailed configuration information, for example a frame header, to be stored with the compressed data and transferred between the encoder and decoder. However, transmitting and storing the configuration information is a disadvantage because it increases both the amount of memory needed to store the compressed data and the amount of data that needs to be communicated within the media device.

What is needed, therefore, is a system and method that facilitates independent and selective access to segments of compressed data. What is also needed is a system and method that facilitates decoding segments of compressed data in a different order than they were encoded in. What is also needed is a system and method for compressing data that does not create data dependencies within the compressed data. What is also needed is a system and method that eliminates the need to transfer configuration information between the encoder and decoder.

SUMMARY

The present invention overcomes the problems associated with the prior art, by providing a system and method that facilitates randomly accessing segments of compressed data stored in a memory. The invention facilitates compressing segments of data without introducing data dependencies between compressed data segments. The invention also facilitates generating locators that indicate the locations associated compressed data segments in memory. As a result, any of the compressed data segments can be retrieved from memory and

decoded in any order, without requiring other compressed data segments to also be decoded.

A method according to the present invention facilitates random access to segments of compressed data stored in memory. The method includes the steps of receiving a series of data segments, encoding the series of data segments into a series of compressed data segments having variable segment sizes, storing the series of compressed data segments in a compressed data memory, optionally free of header information, and generating a locator for each of the compressed data segments. Each locator is indicative of the location of an associated compressed data segment in the compressed data memory. Particular methods can also include the steps of determining the size of each of the compressed data segments in the series and/or storing the locators in a locator memory for later retrieval.

According to a particular method, the locator includes a memory address identifying a memory location in the compressed data memory storing at least part of the associated compressed data segment and an offset that identifies the position of the first bit of the associated compressed data segment within the identified memory location. In a more particular method, a locator for an associated compressed data segment is generated by calculating a sum of the sizes of each of the compressed data segments stored prior to the associated compressed data segment, dividing the sum by a value equal to the width of the compressed data memory to obtain a quotient and a remainder, converting the quotient to the memory address of the locator, and setting the offset of the locator equal to the remainder. According to another particular method, the locator can be a memory pointer.

According to a particular method, the series of data segments comprises a series of blocks of image data defining an image, and the compressed data memory is a frame buffer. According to such a method, the step of encoding the data segments can include performing a discrete cosine transform (DCT) on each block of image data to generate a series of blocks of absolute DCT coefficients, which are DCT coefficients that are generated without reference to any other block of DCT coefficients. The step of encoding can also include, for each block of DCT coefficients, the steps of quantizing the block of DCT coefficients to produce a block of quantized coefficients, zig-zag encoding the block of quantized coefficients into a sequence of quantized coefficients, run-length-encoding the sequence of quantized coefficients to produce run-length-encoded data (RLE) data, and entropy encoding the RLE data to produce one of the series of compressed data segments. Optionally, the quantization data and entropy data used during the steps of quantization and entropy encoding does not change between images.

A method for randomly accessing a compressed data segment from the compressed data memory is also disclosed. One method of the invention includes the steps of receiving a request for a compressed data segment, retrieving a locator associated with the requested compressed data segment, using the retrieved locator to locate the requested compressed data segment within the series of compressed data segments stored in the compressed data memory, and retrieving the requested compressed data segment. A particular method further includes the steps of retrieving a second locator associated with a second compressed data segment stored in the compressed data memory after the requested compressed data segment, and using the second locator to locate and end of the requested compressed data segment.

Another particular method includes the step of decoding the compressed data. Thus, the invention enables a compressed data segment to be retrieved and decoded out of order with the rest of the series of compressed data segments. In the case of an image, the step of decoding the compressed data segment can include the steps of entropy decoding the requested compressed data segment to produce RLE data, run-length decoding the RLE data to produce a plurality of quantized coefficients, performing an inverse zig-zag process on the plurality of quantized coefficients to produce a block of quantized coefficients, dequantizing the block of quantized coefficients to produce a block of absolute DCT coefficients, and performing an inverse DCT process on the block of absolute DCT coefficients without reference to any other block of DCT coefficients to produce a block of decoded image data. According to a more particular method, the step of decoding can be performed without parsing a header associated with the series of compressed data segments.

Non-transitory, electronically-readable storage medium having code embodied therein for causing an electronic device to perform the above methods of the invention are also described. The term "non-transitory" is intended to distinguish storage media from transitory electrical signals. However, re-writable memories are intended to be "non-transitory".

The present invention also describes systems facilitating random access to segments of compressed data stored in a compressed data memory. According to one embodiment, the system includes a data input coupled to receive a series of data segments, an encoder operative to encode the series of data segments into a series of compressed data segments having variable segment sizes, a compressed data memory coupled to receive and store the series of compressed data segments, and a locator generator operative to generate a locator for each of the series of compressed data segments, where the locator is indicative of the location of an associated compressed data segment in the series.

Particular embodiments of the encoder of the present invention can be implemented to perform any of the particular encoding methods described above, particularly with respect to the absolute DCT-, quantization-, zig-zag-, run-length-, and entropy-encoding processes for encoding blocks of image data into compressed data segments. Particular embodiments of the locator generate of the present invention can also be implemented to generate locators according to the above-described methods, particularly with respect to determining the sizes of the compressed data segments and using the sizes to generate the locators. Furthermore, any of the above-described formats for the locators can also be implemented in particular embodiments of the present invention.

A system for randomly accessing a segment of compressed data from memory is also disclosed. According to one embodiment, the system includes a data request input operative to receive a request for at least one compressed data segment selected from a series of variable-size compressed data segments stored in the compressed data memory. The embodiment also includes a controller that is operative to retrieve a locator associated with the requested compressed data segment, to use the retrieved locator to locate the requested compressed data segment in the compressed data memory, and to retrieve the requested compressed data segment from memory. In a more particular embodiment, the controller can also retrieve a second locator associated with a second compressed data segment stored in the compressed data memory and then use the second locator to locate the end of the requested compressed data segment.

The system can also include a decoder operative to decode the requested compressed data segments. In a particular embodiment, the decoder can use inverse entropy, inverse run-length, inverse zig-zag, inverse quantization, and inverse DCT processes to decode the compressed data segment. In another particular embodiment, the decoder can decode the requested compressed data segment without parsing a compressed data header.

A data structure for a locator for locating an associated compressed data segment in memory is also disclosed. The data structure can be stored in a non-transitory, electronically-readable storage medium. In a particular embodiment, the data structure includes a first field storing data defining a memory address identifying a memory location in the memory in which at least a portion of the associated compressed data segment is stored. The data structure also includes a second field storing data defining an offset, where the offset is indicative of a bit position within the memory location where the associated compressed data segment begins. In a more particular embodiment, the data structure further includes a third field storing data uniquely identifying the associated compressed data segment from a plurality of other compressed data segments.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is described with reference to the following drawings, wherein like reference numbers denote substantially similar elements:

FIG. **1** is a block diagram of a host device that includes an encoder and decoder (codec) system according to one embodiment of the present invention;

FIG. **2** is a diagram illustrating how an image can be divided into a plurality of data segments according to the present invention;

FIG. **3** is a block diagram showing the encoder of FIG. **1** in greater detail, according to one embodiment of the present invention;

FIG. **4** is a diagram showing the Discrete Cosine Transform (DCT) unit of FIG. **3** performing a DCT on a block of image data according to the present invention;

FIG. **5** is a block diagram showing the entropy and locator unit (ELU) of FIG. **3** in greater detail, according to one embodiment of the present invention;

FIG. **6** shows a data structure for a locator, according to one embodiment of the present invention;

FIG. **7** shows the locator buffer of FIG. **1** storing a plurality of locators according to one embodiment of the present invention;

FIG. **8** shows the compressed data memory of FIG. **1** storing a series of compressed data segments associated with the locators of FIG. **7** according to one embodiment of the present invention;

FIG. **9** is a block diagram showing the Random Access Controller of FIG. **1** in greater detail, according to one embodiment of the present invention;

FIG. **10** is a block diagram showing the decoder of FIG. **1** in greater detail, according to one embodiment of the present invention;

FIG. **11** is a block diagram of a computer system showing the codec system of the present invention implemented in software, according to one embodiment of the present invention;

FIG. **12** is a flowchart summarizing a method of facilitating random access to segments of compressed data stored in a memory, according to the present invention;

FIG. **13** is a flowchart summarizing a particular method of performing the second step (encode the series of data segments) of the method of FIG. **12**, according to the present invention;

FIG. **14** is flowchart summarizing a particular method of performing the fourth step (generate locator) of the method of FIG. **12** according to the present invention; and

FIG. **15** is a flowchart summarizing a method of randomly accessing a segment of compressed data from memory, according to the present invention.

DETAILED DESCRIPTION

The present invention overcomes the problems associated with the prior art, by providing a system and method that facilitates randomly accessing segments of compressed data stored in a memory. In the following description, numerous specific details are set forth (e.g., particular routines and components for generating locators, data trimming practices, etc.) in order to provide a thorough understanding of the invention. Those skilled in the art will recognize, however, that the invention may be practiced apart from these specific details. In other instances, details of well-known data compression practices (e.g., particular encoding and decoding techniques, routine optimization) and components have been omitted, so as not to unnecessarily obscure the present invention.

FIG. **1** is a block diagram of a host device **100** that includes an encoder and decoder (codec) system **102** according to one embodiment of the present invention. Codec system **102**, among other advantages, facilitates randomly accessing segments of compressed data stored in a compressed data memory **104**. Codec system **102** includes an encoder **106** including a locator generator **108**, a decoder **110**, a locator buffer **112**, and a random access controller (RAC) **114**. Uncompressed data is provided to codec system **102** via a data input **116**, and decoded data is provided from codec system **102** via a decoded data output **118**. Data requests to randomly access segments of compressed data from compressed data memory **104** are provided from host device **100** via data request input **120**.

Host device **100** represents any system or device that would benefit from the ability to encode (compress) data, decode (decompress) data, and/or randomly retrieve and decode the segments of compressed data stored in compressed data memory **104**. In the present embodiment, host device **100** is an image processor and codec system **102** facilitates randomly accessing segments of a compressed image (e.g., a compressed frame of video) stored in compressed data memory **104**. Host device **100** can be implemented, for example, in integrated circuitry, software, etc. and/or any combination thereof.

The components of codec system **102** operate as follows. Encoder **106** receives a series of uncompressed data segments via data input **116**, encodes the series of data segments into a series of compressed data segments, and provides the series of compressed data segments to compressed data memory **104** via data path **124**. As will be described in more detail below, encoder **106** provides a means for encoding each of the data segments independently of any other of the compressed data segments. In one embodiment, encoder **106** is similar to a Joint Photographic Experts Group (JPEG) encoder but is not constrained by the JPEG compression standard or its associated file formats (e.g., JIF, Exif, JFIF, etc.).

Encoder **106** includes a locator generator **108** that generates a locator for each of the compressed data segments in the series. Each locator advantageously indicates a location in the compressed data memory **104** where an associated compressed data segment is stored. Locator generator **108** stores a locator for each of the series of compressed data segment in the locator buffer **112** via data path **126**. Thus, locator generator **108** and the generated locators are means for locating the compressed data segments in the compressed data memory. While locator generator **108** is shown incorporated in encoder **106** in FIG. **1**, locator generator **108** can alternatively be embodied outside of encoder **106**.

Compressed data memory **104** receives the series of compressed data segments from encoder **106** via data path **124** and stores each of the compressed data segments therein. Decoder **110** can read compressed data segments directly from compressed data memory **104** via data path **128** (e.g., when decompressing a whole image). Additionally, RAC **114** can read compressed data segments from compressed data memory **104** via data path **130** in any order, (e.g., when decompressing only portions of an image), and provide those to compressed data segments to decoder **110** via data path **134**.

In the present embodiment of the invention, compressed data memory **104** is a frame buffer adapted to contiguously store a series of compressed data segments associated with an image (e.g., a frame of video) in a plurality of memory locations. Compressed data memory **104** can be implemented within host device **100** or, alternatively, can be a memory external to host device **100**. As another example, compressed data memory **104** can be a memory dedicated to codec system **102**.

Locator buffer **112** receives and stores the locators from encoder **106** via data path **126**. Each locator is stored in locator buffer **112** such that it can be associated with the corresponding compressed data segment. Locator buffer **112** also provides locators to RAC **114** via data path **132** when requested by RAC **114**. While locator buffer **112** is shown as being a memory within codec system **102**, it should be understood that locator buffer **112** can be implemented anywhere in host device **100** or even externally to host device **100**.

RAC **114** utilizes the locators in locator buffer **112** to retrieve one or more compressed data segments from compressed data memory **104** and to provide those compressed data segments to decoder **110** in any order indicated by the data requests received on data request input **120**. In particular, RAC **114** receives requests for data segments via data request input **120** from host device **100**. RAC **114** retrieves locators for the requested data segments via data path **132** and then reads the requested compressed data segments from compressed data memory **104** via data path **130**. RAC **114** then provides the one or more requested compressed data segments to decoder **110** for decoding via data path **134**. As indicated above, host device **100** can request data segments in any desired sequence, and RAC **114** will read the corresponding compressed data segments from compressed data memory **104** and decoded according to that sequence.

Decoder **110** receives compressed data segments from compressed data memory **104** and RAC **114** via data paths **128** and **134**, respectively, and decodes those compressed data segments. Decoder **110** then provides decoded data segments via decoded data output **118** to host device **100** for further use as requested by host device **100**. As will be described more below, in one embodiment decoder **110** is similar to a JPEG decoder but is not constrained by the JPEG compression standard and its associated file formats.

FIG. **1** also shows that host device **102** includes a timing and control unit **136**, which provides timing and other control signals (e.g., clock pulses, enable signals, reset signals, etc.) to the elements of codec system **102** and compressed data memory **104** via a timing and control path **138**. The timing and other control signals provided by timing and control unit **136** enable codec system **102** and compressed data memory **104** to carry out their intended functions and to move data through codec system **102** and compressed data memory **104** at the appropriate times and in the appropriate orders.

Timing and control unit **136** and timing and control path **138** are shown representationally. However, those skilled in the art will realize that timing and control unit **136** and timing and control path **138** can be implemented in various ways (e.g., separate units and busses for timing signals and control signals, separate units for host device **100** and codec system **102**, etc.). Additionally, timing and control elements can also be implemented inside codec system **102**.

FIG. **2** is a diagram illustrating how an image **200** (e.g., a frame of video) can be divided into a plurality of data segments **202**(**1**)-**202**(*n*). As shown in detail **204**, each data segment **202**(**1**)-**202**(*n*) includes image data for an 8-by-8 block of pixels **206** of the image **200**. Therefore, if image **200** has 1280×720 pixels, it can be divided into 160×90 (i.e., 14,400) blocks of image data, with each block **202**(**1**)-**202**(**14400**) defining a uniform amount of pixel data.

In the present embodiment, host device **100** is responsible for dividing each image **200** into an array of data segments **202**(**1**)-**202**(*n*) (hereinafter, referred to as blocks **202**(**1**)-**202**(*n*)) and providing the blocks **202**(**1**)-**202**(*n*) as a series to data input **116** of codec system **102**. Host device **100** also provides the series of blocks **202**(**1**)-**202**(*n*) to codec system **102** in a predetermined sequence known to the host device **100** and to the components of codec system **102**. In the present embodiment, host device **100** provides the blocks **202**(**1**)-**202**(*n*) in a sequence beginning with block **202**(**1**) in the top left of the array, moving to the end of the first row, and then moving row-by-row down the array, ending with block **202**(*n*) in the bottom right of the array. Thus, for the array shown in FIG. **2**, the sequence would be blocks **202**(**1**, **1**), **202**(**2**, **1**), . . . **202**(*i*, **1**), **202**(**1**, **2**), **202**(**2**, **2**), . . . **202**(*i*, **2**), . . . **202**(**1**, j), **202**(**2**, j), . . . and ending with block **202**(*i, j*).

In the present embodiment, host device **100** can also format each image **200** for compatibility with codec system **102**. For example, host device **100** can convert an image from one color space (e.g., Red, Green, Blue (RGB), etc.) into another color space (e.g., YCbCr, etc.). Additionally, host device **100** can also separate an image into its color space components (e.g., Y, Cb, Cr; etc.), such that multiple images **200** are generated for each composite image. In such a case, each image **200** would include data for only one of the color space components of the composite image. These and other block preparation techniques are available to host device **100**.

While host device **200** is responsible for block preparation in the present embodiment prior to providing image data to encoder **106**, it will be appreciated that encoder **106** could also prepare the series of blocks **202**(**1**)-**202**(*n*) for encoding.

FIG. **3** is a block diagram showing encoder **106** of FIG. **1** in greater detail, according to one embodiment of the present invention. Encoder **106** includes a Discrete Cosine Transform (DCT) unit **302**, a quantization unit **304**, a zig-zag unit **306**, a run-length encoder **308**, and an entropy and locator unit (ELU) **310**.

Encoder **106** sequentially receives a series of blocks **202**(**1**)-**202**(*n*) of uncompressed (raw) image data on an encoder input path **312** from host device **100** according to the predetermined sequence discussed above. Encoder **106** receives and encodes each block **202**(**1**)-**202**(*n*) in the series as follows.

DCT unit **302** receives each block **202**(**1**)-**202**(*n*) of image data and performs an absolute DCT on the block **202**, whereby the block **202** of image data is transformed into an 8-by-8 block of 64 DCT coefficients in the frequency domain. As will be described in more detail below, the DCT is performed such that all of the DCT coefficients in the block are absolute values. Because all of the DCT coefficients in each block of DCT coefficients are absolute values, there are no block-to-block data dependencies introduced into the series of compressed data segments generated by encoder **106**. Thus, DCT unit **302** can be considered an absolute DCT unit **302**, which performs an absolute DCT on each block **202** of image data. DCT unit **302** provides each resulting block of DCT coefficients to quantization unit **304** via data path **314**.

Quantization unit **304** receives each block of absolute DCT coefficients and quantizes the block of DCT coefficients using default quantization data **316** to produce an 8-by-8 block of quantized coefficients. In the present embodiment, default quantization data **316** is a default quantization table, but could alternatively include a default quantization value used to quantize all DCT coefficients. Quantization unit **304** quantizes the block of DCT coefficients by dividing each DCT coefficient by a corresponding quantization value in the default quantization table **316** and then rounding the quotient to the nearest integer.

It should be noted that default quantization data **316** can be stored inside or outside of encoder **106**. For example, default quantization data **316** can be stored in a memory external to encoder **106** accessible by quantization unit **304**. Alternatively, default quantization data **316** can be defined in the integrated circuitry of encoder **106**.

Using the default quantization data **316** to quantize the blocks of DCT coefficients over multiple images **200** provides important advantages. First, because default quantization data **316** does not have to change, quantization data does not have to be provided in a header to decoder **110** to configure the inverse quantization process. Rather, the decoder **110** can be programmed to use the same default quantization data as encoder **106** over multiple images/frames. Moreover, because a header is not needed to transfer the quantization data to decoder **110**, the header can be eliminated instead of being stored with the compressed data in compressed data memory **104**, which increases data compression and reduces data transfer times.

After quantization, quantization unit **304** provides each block of quantized coefficients to zig-zag unit **306** via data path **318**. Zig-zag unit **306** receives each block of quantized coefficients from quantization unit **304** and performs a "zig-zag" operation on the block. The zig-zag operation arranges the block of quantized coefficients into a linear sequence by "zig-zagging" along the diagonals of the block, as is known in the art. For each block of quantized coefficients, zig-zag unit **306** outputs a linear sequence of quantized coefficients to run-length encoder **308** via data path **320**.

Run-length encoder **308** receives a linear sequence of quantized coefficients associated with the block **202** from zig-zag unit **306** and encodes the linear sequence into run-length-encoded (RLE) data associated with the block. Run-length encoding is a well-known form of data compression in which runs of data having the same value (e.g., zero) are stored as a count. A particular method for run-length encoding stores the plurality of quantized coefficients associated with the block **202** of image data as pairs of values, each pair having a first value defining a run of zeros and a second value indicating the next non-zero quantized coefficient. The method also includes using an end-of-block (EOB) code to indicate that all remaining quantized coefficients associated with the block **202** have a value of zero. Once the RLE data is generated, it is provided to ELU **310** via data path **322**.

ELU **310** receives the RLE data associated the block **202** and entropy encodes it into entropy-encoded data (EED), thereby defining a compressed data segment associated with the block **202** of image data. In the entropy-encoding process, frequently-occurring RLE data is encoded using shorter codes and infrequently-occurring RLE data is encoded using longer codes. One type of entropy encoding is known in the art as Huffman encoding. Entropy codes used to encode the RLE data are stored as default entropy data **324** (e.g., a default entropy look-up table) that is available to ELU **310**. Once entropy encoding is complete, ELU **310** provides the compressed data segment associated with the block **202** of image data to compressed data memory **104** via an encoder output path **328**, and data path **124**.

Like default quantization data **316**, default entropy data **324** can be stored externally to encoder **106** so long as entropy encoder **310** has access to it. Moreover, default entropy data **324** provides the same advantages as default quantization data **316**. In particular, because default entropy data **324** does not change between blocks **202**(**1**)-**202**(*n*) or between images **200**, entropy data (e.g., an entropy table) does not have to be provided in a header with the compressed data to decoder **110** to configure its inverse entropy process. Rather, decoder **110** will be programmed to use the same default entropy data **324** as encoder **106**. Furthermore, header information containing entropy data also does not have to be stored in compressed data memory **104**, thereby saving improving data compression and data transfer times.

In addition to being an entropy encoder, ELU **310** also provides the functionality of locator generator **108** (FIG. **1**). For each compressed data segment associated with a block **202**(**1**)-**202**(*n*), ELU **310** generates a locator indicating where that compressed data segment is stored in compressed data memory **104**. Because the encoding process of encoder **106** yields a series of compressed data segments, wherein each compressed data segment has a variable segment size, the locators generated by ELU **310** advantageously facilitate locating and extracting any of the compressed data segments from compressed data memory **104**. According to one embodiment of the invention, ELU **310** determines and utilizes the variable segment sizes of the compressed data segments to generate their associated locators. Once a locator is generated for a compressed data segment that is associated with the block **202** of image **200**, ELU **310** stores the locator in locator buffer **112** (FIG. **1**) via data path **126** and stores the compressed data segment associated with the block **202** in compressed data memory **104**.

Thus, for a given image **200**, encoder **106** generates a series of compressed data segments that are stored in compressed data memory **104**, where each of the series of compressed data segments is associated with one of the blocks **202**(**1**)-**202**(*n*) of image **200**. Each of the series of compressed data segments is also associated with one of the locators generated by ELU **310** and stored in locator buffer **112**. Thus, each of the locators stored in locator buffer **112** is also associated with one of blocks **202**(**1**)-**202**(*n*) of image **200**.

FIG. **4** is a diagram showing DCT unit **302** of FIG. **3** performing a DCT on one of blocks **202**(**1**)-**202**(*n*) of image data. As shown in FIG. **4**, DCT unit **302** transforms each 8-by-8 block **202** of image data into an 8-by-8 block **402** of DCT coefficients in the frequency domain. Each block **402** of DCT coefficients includes one DC coefficient **404** and **63** AC coefficients **406**(**1**)-**406**(**63**). As indicated above, the coefficients **404** and **406**(**1**)-**406**(**63**) in each block **402** of DCT coefficients are absolute values, such that data dependencies are not introduced into the series of compressed data segments.

DCT processes are well-known in the art. The DCT process tends to aggregate large DCT coefficients in the top left of the block of DCT coefficients. Therefore, it is common for the absolute value of the DC coefficient to be quite large, especially compared to the absolute values of the AC coefficients.

In an effort to increase data compression, prior art encoders (e.g., JPEG encoders, etc.) encode the DC coefficient as the difference between the absolute DC coefficient for a current block and another value, such as the absolute DC coefficient of the previous block. This is process is commonly termed "prediction differencing". Encoding this difference rather than the absolute DC coefficient value results in better data compression, but it also has the drawback that it introduces data dependencies between consecutive blocks of DCT coefficients. As a result, a subsequent block of DCT coefficients in the prior art cannot be decoded without also decoding the previous block of DCT coefficients. Thus, the prior art is said to use a "relative" DCT encoding technique, which requires the prior art decoder to use a first-in-first-out decoding technique.

In contrast to the prior art, the DCT unit **302** of the present invention encodes an absolute value for the DC coefficient **404** (and for each of the AC coefficients **406**(**1**)-**406**(**63**)) for each block **402** of DCT coefficients that it generates. Therefore, the values of the DCT coefficients in each block **402** are independent of the coefficient values in the other blocks **402** of DCT coefficients. While DCT unit **302** gives up some data compression (approximately 5% or less) due to the larger absolute DC coefficient **404**, it has the advantage that no data dependencies are introduced into the blocks **402** of DCT coefficients. Thus, according to the invention, one compressed data segment can be randomly retrieved from compressed data memory **104** and decoded without having to retrieve and decode any other compressed data segments. Furthermore, any data compression lost by encoding the absolute DCT coefficient values is compensated for, because configuration data (e.g., a header with quantization and entropy data, etc.) is not stored in compressed data memory **104**.

FIG. **5** is a block diagram showing ELU **310** (FIG. **3**) in greater detail, according to one embodiment of the invention. As shown in FIG. **5**, ELU **310** includes an entropy encoder **502**, an address and offset determination (AOD) unit **504**, and an accumulated size register **506**. In the present embodiment, entropy encoder **502**, AOD unit **504**, and accumulated size register **506** implement locator generator **108** (FIG. **1**). FIG. **5** also shows that ELU **310** includes (or has access to) default entropy data **324**.

Entropy encoder **502** receives RLE data associated with each block **202**(**1**)-**202**(*n*) of image data via data path **322**. For each block **202**(**1**)-**202**(*n*), entropy encoder **502** encodes the RLE data with that block **202** into entropy-encoded data (EED) using the default entropy data **324**. The EED represents a compressed data segment associated with the block **202**, which will be stored in compressed data memory **104**.

Entropy encoder **502** also determines the size of the compressed data segment associated with each block **202**(**1**)-**202**(*n*), wherein the size represents the amount of memory the compressed data segment will occupy in compressed data store **104**. Because the EED is serial data, the size of the compressed data segment can be expressed as a bit length of the compressed data segment. Entropy encoder **502** communicates the size (bit length) of the compressed data segment associated with each block **202**(**1**)-**202**(*n*) to AOD unit **504** via data path **508**. Entropy encoder **502** also provides the compressed data segment to compressed data store **104** via encoder output path **328**.

AOD unit **504** generates a locator for each compressed data segment of an associated block **202**, which can be used to locate and retrieve the compressed data segment from compressed data memory **104**. In the present embodiment, AOD unit **504** determines a locator for each compressed data segment based on the accumulated size value stored in accumulated size register **506** and the width of compressed data memory **104**. AOD unit **504** also stores locators in locator buffer **112** via data path **126**. AOD unit **504** is also operative to accumulate the sizes of the compressed data segments by adding the size of each compressed data segment associated with an image **200** to accumulated size register **506**.

Accumulated size register **506** stores the accumulated size of the compressed data segments associated with the blocks **202**(**1**)-**202**(*n*) of image **200** as those blocks are encoded. Before an image **200** is encoded using encoder **106**, accumulated size register **506** is reset, for example by a reset signal received on timing and control path **138**. As entropy encoder **502** generates sizes for each successive compressed data segment, AOD **504** will accumulate the size values, segment-by-segment, in accumulated size register **506**. Thus, for any given block **202**(*b*) of the image **200** being encoded, accumulated size register **506** stores the total size of the compressed data segments associated with all previously-encoded blocks **202**(**1**)-**202**(*b*-**1**) of the image **200**.

FIG. **6** shows a data structure for each locator **600** generated by AOD unit **504**, according to one embodiment of the present invention. As shown, each locator **600** includes a first field **602**, a second field **604**, and an optional third field **606**.

First field **602** contains data identifying a memory location (e.g., a memory address) within compressed data memory **104** where the compressed data segment associated with the locator **600** begins. In the present embodiment, compressed data memory **104** is a 64-bit wide frame buffer. Accordingly, first field **602** contains a memory address that identifies a 64-bit wide memory location in compressed data memory **104**. The number of bits needed to define the memory addresses stored in first field **602** will depend on the size of compressed data memory **104**.

Second field **604** contains data identifying a bit offset from the beginning of the memory location identified by the memory address in first field **602**. In the present embodiment, the bit offset indicates the number of bits of data starting from the beginning of the memory location that are not part of the compressed data segment associated with the locator **600**. The compressed data segment associated with the locator **600**, therefore, begins with the bit following a number of bits in the memory location equal to the bit offset. The number of bits used in the second field **64** to define the bit offset will depend on the width of the memory locations in compressed data memory **104**. For 64-bit wide memory locations, second field **604** can be defined using six bits of data.

Third field **606** includes data associating locator **600** with one of blocks **202**(**1**)-**202**(*n*) of image **200**. For example, each block **202**(**1**)-**202**(*n*) in image **200** could be assigned a unique identifier, which is provided in third field **606** when the locator **600** is generated. The identifier **600** could then be used by RAC **114** to retrieve the locator. In the present embodiment, however, third field **606** is optional because the locators **600** can be stored in consecutive memory locations in locator buffer **112** in the same predetermined sequence in which the blocks **202**(**1**)-**202**(*n*) are encoded.

AOD **504** generates each locator **600** as follows. For each compressed data segment, AOD **504** calculates the sum of the sizes of all the previous compressed data segments generated for image **200**. In the embodiment shown in FIG. **5**, AOD **504** obtains this sum by reading the value stored in accumulated size register **506**. AOD **504** then divides this sum by the width (64 bits in the present embodiment) of compressed data memory **104** to obtain a quotient and a remainder, both expressed as integers. AOD **504** then converts (e.g., via a lookup table, etc.) the quotient to an address of a memory location in compressed data memory **104**. This memory location is where the compressed data segment will begin in compressed data memory **104**. AOD **504** then generates the locator **600** using the resulting memory address as field **602** and the remainder as the bit offset in field **604**. Once the locator **600** for the current compressed data segment is generated, AOD **504** adds the size of the current compressed data segment (previously obtained from entropy encoder **502**) to the accumulated value stored in the accumulated size register **506**, such that the accumulated size value is updated to generate the locator **600** associated with the next compressed data segment.

AOD **504** can also generate locators **600** with the optional third field **606**, for example, by counting the number of times entropy encoder **502** provides it with a size value. AOD **504** can then use this count value to supply third field **606** with a value that associates the locator **600** with a particular block **202** of image data. In such a case, the count value used by AOD **504** would be reset each time a new image **200** is encoded, for example by a reset signal received via timing and control path **138**.

AOD **504** can also be operative to generate an optional "end locator" (FIG. **7**) that indicates the end of the compressed data segment associated with the last block **202**(*n*) of the image **200** within compressed data memory **104**. The end locator provides the advantage that it enables RAC **114** to locate the end of this compressed data segment and "trim" any data that is not part of it before providing the compressed data segment to decoder **110**. AOD **504** generates the end locator after the locator **600** associated with the last block **202**(*n*) is generated and before a next image **200** is encoded. The end locator can include the same fields as the locators **600**. AOD **504**, for example, can generate the end locator using the accumulated size value for the compressed data segments associated with all of blocks **202**(**1**)-**202**(*n*) stored in accumulated size register **506** and the algorithms described above for generating fields **602** and **604**. Additionally, AOD **504** can provide the end locator with a third field that uniquely identifies the end locator.

FIG. **7** shows a data structure for locator buffer **112** (FIG. **1**) for storing a plurality of locators **600**(**1**)-**600**(**14400**) associated with a 1280×720 image **200**, according to the present invention. Locators **600**(**1**)-(**14400**) locate the compressed data segments associated with blocks **202**(**1**)-**202**(**14400**) of the image **200**, respectively, in compressed data memory **104**. Locator buffer **112** is also configured to store an end locator **700**, as shown.

In the present embodiment, a 1280×720 image is the largest image that host device **100** and codec system **102** process. Therefore, locator buffer **112** includes sufficient memory to store locators for any image up to 1280×720 pixels in size. Those skilled in the art will realize that the number of locators **600** that locator buffer **112** should be able to store will vary with the resolution of the images to be compressed.

In the present embodiment, locator buffer **112** sequentially receives and stores locators **600**(**1**)-**600**(**14400**) from encoder **106** in consecutive memory locations, beginning with a predetermined memory location. Thus, the locator **600**(**1**) associated with block **202**(**1**) is stored in a first memory location, the locator **600**(**2**) associated with block **202**(**2**) is stored in a second memory location, and so on until the last locator **600**(**14400**) associated with the last block **202**(**14400**) is stored. An end locator **700** is then stored after the last locator **600**(**14400**) as shown. Because blocks **202**(**1**)-**202**(**14400**) are supplied to encoder **106** in a known predetermined order, the locators **600**(**1**)-**600**(**14400**) are generated and stored in the same known, predetermined order. Therefore, the locator **600** associated with any particular block **202** of the image **200** can be readily identified and retrieved from locator memory **112** by RAC **114**. Accordingly, the third field **606** of the locators **600(1)-600(14400)** is optional in the present embodiment. However, the third field **606** could otherwise facilitate identifying a particular locator **600** as being associated with a particular block **202** if the locators **600** were stored at random locations in locator buffer **112**.

It should also be noted that the memory locations of locator buffer **112** can be reset between the encoding of consecutive images **200** (e.g., via a reset signal received via timing and control path **138**), or at other predetermined times. Resetting the locator buffer **112** for each image would ensure that the locators **600** stored therein did not become corrupted, for example, if the resolution of successive encoded images changed.

FIG. **7** shows locators **600(1)-600(5)**, and **600(14400)**, and end locator **700** for hypothetical compressed data segments associated with blocks **202(1)-202(5)** and **202(14400)** of an image **200**. For the following explanation, it will be assumed that the sizes (data length) of the compressed data segments associated with blocks **202(1)-202(4)** and **202(14400)** are 37 bits, 32 bits, 43 bits, 83 bits, and 75 bits, respectively.

For the first block **202(1)**, the first field **602** of locator **600(1)** indicates that the compressed data segment associated with the first block **202(1)** of image **200** begins in memory location zero of compressed data memory **104**. The second field **604** of locator **600(1)** further indicates that the compressed data segment associated with block **202(1)** begins with the first bit in memory location zero, because the bit offset is zero. Because the compressed data segment associated with block **202(1)** is 37 bits long, it occupies the first 37 bits of memory location zero. AOD **504** generated locator **600(1)** by dividing the sum of the bit lengths of the previously-compressed data segments for image **200** (in this case zero) by 64 (the width of the memory locations in compressed data memory **104**), to obtain the resulting quotient of zero and remainder of zero. This quotient was then converted to the address for memory location zero and stored in first field **602**, and the remainder was stored as the bit offset in second field **604**.

Locator **600(2)** indicates that the compressed data segment associated with the second block **202(2)** of image **200** begins in memory location zero (first field **602**) after the 37^{th} bit (second field **604**). (Recall the first 37 bits are occupied by the compressed data segment associated with the first block **202(1)**.) AOD **504** generated locator **600(2)** by dividing the sum of the bit lengths of the previously-compressed data segments for image **200** (in this case the sum is 37, which is stored in accumulated size register **506**) by 64, to obtain the resulting quotient of zero and the remainder of 37. This quotient is then converted to the address for memory location zero and stored in first field **602**, and the remainder is stored as the bit offset in second field **604**.

Locator **600(3)** indicates that the compressed data segment associated with the third block **202(3)** of image **200** begins in memory location one (first field **602**) after the fifth bit (second field **604**). (The first five bits are occupied by the compressed data segment associated with the second block **202(2)**.) AOD **504** generated locator **600(3)** by dividing the sum of the bit lengths of the previously-compressed data segments for image **200** (in this case the sum of 37 bits+32 bits, which is stored in accumulated size register **506**) by 64, to obtain the resulting quotient of one and remainder of five. This quotient is then converted to the address for memory location one and stored in first field **602**, and the remainder is stored as the bit offset in second field **604** of locator **600(3)**.

Locator **600(4)** indicates that the compressed data segment associated with the fourth block **202(4)** of image **200** begins in memory location one (first field **602**) after the 48^{th} bit (second field **604**). (The first 48 bits are occupied by the compressed data segment associated with the third block **202(3)**.) AOD **504** generated locator **600(4)** by dividing the sum of the bit lengths of the previously-compressed data segments (in this case the sum of 37 bits+32 bits+43 bits, which is stored in accumulated size register **506**) by 64, to obtain the resulting quotient of one and remainder of 48. This quotient is then converted to the address for memory location one and stored in first field **602**, and the remainder is stored as the bit offset in second field **604** of locator **600(4)**.

Locator **600(5)** indicates that the compressed data segment associated with the fifth block **202(5)** of image **200** begins in memory location three (first field **602**) after the third bit (second field **604**). (The first three bits are occupied by the compressed data segment associated with the fourth block **202(4)**.) AOD **504** generated locator **600(5)** by dividing the sum of the bit lengths of the previously-compressed data segments for image **200** (in this case the sum of 37 bits+32 bits+43 bits+83 bits) by 64, to obtain the resulting quotient of three and remainder of three. This quotient is then converted to the address for memory location three and stored in first field **602**, and the remainder is stored as the bit offset in second field **604**.

Locator **600(14400)** indicates that the compressed data segment associated with the last block **202(14400)** of image **200** begins in memory location **7192** (first field **602**) after the 17^{th} bit (second field **604**). Additionally, end locator **700** indicates that the compressed data segment associated with block **202(14400)** ends in memory location **7193** (first field **602**) with the 28^{th} bit in that memory location. AOD **504** generated end locator **700** by dividing the sum of the bit lengths of all the compressed data segments for image **200** (which stored in accumulated size register **506** after locator **600(14400)** is generated) by 64, to obtain the resulting quotient of 7193 and remainder of 28. This quotient is then converted to the address for memory location **7193** and stored in first field **702**, and the remainder is stored in second field **704**, indicating the last bit of the compressed data segment associated with block **202(14400)**.

FIG. **8** shows compressed data memory **104** (FIG. **1**) storing the series of hypothetical compressed data segments associated with locators **600(1)-600(5)** and **600(14400)** of FIG. **7**. Compressed data memory **104** includes a plurality of addressable memory locations **802(0)-802(*x*)**. The number of memory locations **802(0)-802(*x*)** shown in compressed data memory **104** is exemplary in nature, and can vary by application and compression ratio, and should not be construed as limiting the invention. As shown in FIG. **8**, each memory location **802(0)-802(*x*)** is 64 bits wide.

Compressed data memory **104** stores the series of compressed data segments **804(1)-804(*n*)** associated with blocks **202(1)-202(*n*)** of image **200** contiguously in the memory locations **802(0)-802(*x*)**. In the hypothetical example shown, the series of compressed data segments **804(1)-804(14400)** associated with the blocks **202(1)-202(14400)** of the 1280×720 pixel image **200** occupy memory locations **802(0)-802(7193)**. The memory locations **802(1)-802(*x*)** of compressed data memory **104** may be cleared as needed (e.g., between consecutive images, etc.), for example by a reset signal received via timing and control path **138**.

The locators **600(1)-600(14400)** indicate the locations of the associated compressed data segments **804(1)-804(14400)** within the memory locations **802(0)-802(7193)**. For example, compressed data segment **804(1)** begins with the first bit in memory location **802(0)**, as indicated by locator **600(1)**. Compressed data segment ("C.D.S.") **804(2)** begins after the 37^{th} bit (i.e., begins with the 38^{th} bit) in memory location **802(0)**, as indicated by locator **600(2)**. Compressed data segment **804(3)** begins after the fifth bit in memory location **802(1)**, as indicated by locator **600(3)**. Compressed data segment **804(4)** begins after the 48^{th} bit in memory location **802(1)**, as indicated by locator **600(4)**. Compressed data segment **804(5)** begins after the third bit in memory location **802(3)**, as indicated by locator **600(5)**. This continues to the last compressed data segment **804(14400)** for the image **200**, which begins after the 17^{th} bit in memory location **802(7192)**. End locator **700** finally indicates that the end of compressed data segment **804(14400)** ends with the 28^{th} bit in memory location **802(7193)**.

FIG. **9** is a block diagram showing RAC **114** (FIG. **1**) in greater detail, according to one embodiment of the invention. As shown, RAC **114** receives requests for any of blocks **202(1)-202(*n*)** of image **200** from host device **100** via data request input **120**. The requests from host device **100** provide an indication (e.g., a block identifier, etc.) as to which block(s) **202(1)-202(*n*)** of image **200** that host device **100** wants access to and, accordingly, which compressed data segment(s) stored in compressed data memory **104** need to be decoded. For each requested block, RAC **114** retrieves the associated compressed data segment from compressed data memory **104**, and provides the retrieved compressed data segment to decoder **110** for decoding into a decoded block of image data. RAC **114** provides an important advantage in that it can retrieve and output the compressed data segments from compressed data memory **104** in any order requested by host device **100**. In other words, the invention facilitates randomly accessing and decoding the compressed data segments associated the blocks **202(1)-202(*n*)** of image **200**, in any order.

In FIG. **9**, RAC **114** is shown to include a locator and data retrieval (LDR) unit **902** and a data trimmer **904**, which communicate via a data path **906**. When a request for a block **202** arrives via data request input **120**, LDR unit **902** retrieves the locator **600** associated with the requested block **202**, as well as the locator **600** for the block **202** that was encoded next after the requested block **202**. In the case that the last block **202(*n*)** is requested, LDR unit **902** retrieves the locator **600(*n*)** and the end locator **700**. In the case that a plurality of consecutive blocks **202** are requested, LDR unit **902** retrieves the locator **600** associated with the first block **202** in the requested plurality and the locator for the block **202** that was encoded next after the last block **202** in the requested plurality or the end locator **700**. Thus, in the present embodiment, LDR unit **902** retrieves at least two locators **600**, or one locator **600** and the end locator **700**, for any of the above request types received on data request input **120**.

Because the blocks **202(1)-202(*n*)** of image **200** are encoded in a predetermined sequence and because the locators **600(1)-600(*n*)** and **700** are generated and stored in locator buffer **112** in the same predetermined sequence for each image **200**, LDR unit **902** can retrieve the appropriate locators **600(1)-600(*n*)** and **700** from locator buffer **112** if it knows this predetermined sequence and the memory locations in locator buffer **112** at which the locators **600(1)-600(*n*)** and **700** will be stored. Optionally, the data requests can include identifiers that match the identifiers contained in third field **606** of the locators **600(1)-600(*n*)** and end locator **700**), which LDR unit **902** can use to retrieve the requested locators **600** and end locator **700** from locator buffer **112**.

Using the locators **600** retrieved for a request from host device **100**, LDR unit **902** then retrieves the compressed data segments **804** from compressed data memory **104** between and including the two memory locations **802** identified in the first fields **602** of the retrieved locators **600** or between the two memory locations **802** identified in the first field **602** of the locator **600** and the first field **702** of the end locator **700**. LDR unit **902** then provides the retrieved compressed data and at least the bit offsets contained in second fields **604**, or the bit offset in the second field **604** and the value in the second field **704** of the end locator **700**, to data trimmer **904** via data path **906**.

Data trimmer **904** utilizes the values in the second fields **604** and **704** of the retrieved locators **600** and **700** to trim both ends of the compressed data retrieved from compressed data memory **104**. The bit offset in the second field **604** of the first locator **600** indicates that the first bit of the requested compressed data begins after a number of bits equal to the bit offset. Therefore, data trimmer **904** removes ("trims") a number of bits in the retrieved compressed data equal to this offset. Similarly, the second field **604** of the second locator **600** (or the second field **704** of the end locator **700**) indicates where the compressed data for the last requested block **202** ends. Accordingly, data trimmer **904** removes the portion of the retrieved compressed data after the bit identified in the second field **604** (or second field **704**) of the second locator **600** (or end locator **700**). Once trimmed, data trimmer **904** provides the requested compressed data segment(s) **804** associated with the requested block(s) to decoder **110** via data path **134**.

The following examples with reference to FIGS. **7** and **8** further explain the compressed data retrieval and trimming aspects of the invention. The invention facilitates retrieval and decoding of the compressed data segments of an image **200** independently and in any order.

In a first example, RAC **114** receives a request for the second block **202(2)** of image **200**. Upon receiving the request, LDR unit **902** retrieves locators **600(2)** and **600(3)** from locator buffer **112** via data path **132**. Based on the memory addresses in first field **602** of locators **600(2)** and **600(3)**, LDR unit **902** retrieves the 64 bits of compressed data stored in memory location **802(0)** and the 64 bits of compressed data stored in memory location **802(1)**. LDR unit **902** then provides at least the second field **604** of each of locators **600(2)** and **600(3)**, and the compressed data from memory locations **802(0)** and **802(1)** to data trimmer **904**. Data trimmer **904** utilizes the bit offset in the second field **604** of locator **600(2)** to remove the portion of the compressed data from memory location **802(0)** that is not part of the compressed data for the second block **202(2)**. Specifically, the first 37 bits of compressed data stored in memory location **802(0)** are associated with the compressed data segment for the first block **202(1)** of image **200** and not the second block **202(2)**. Therefore, data trimmer **904** removes these bits from the beginning of the compressed data retrieved from memory location **802(0)**. Data trimmer **904** then utilizes the bit offset in the second field **604** of locator **600(3)** to also remove the portion of the compressed data retrieved from memory location **802(1)** that is not part of the compressed data for the second block **202(2)**. Specifically, the sixth through the last bits of compressed data retrieved from memory location **802(1)** are associated with the third block **202(3)** and not the second block **202(2)**. Therefore, data trimmer **904** removes these bits from the compressed data retrieved from memory location **802(1)**. The resulting compressed data retrieved from memory locations **802(0)** and **802(1)** corresponds to the compressed data segment **804(2)** associated with block **202**

(2). Data trimmer **904** then provides compressed data segment **804(2)** to decoder **110** for decoding via data path **134**.

In a second example, RAC **114** receives a request for blocks **202(2)** through **202(4)** of image **200**. Accordingly, LDR unit **902** retrieves locators **600(2)** and **600(5)** from locator buffer **112** via data path **132**. Based on the memory addresses identified in the first fields **602** of locators **600(2)** and **600(5)**, LDR unit **902** also retrieves the 64 bits of compressed data stored in memory location **802(0)** and memory location **802(3)**, as well as the compressed data stored in intermediate memory locations **802(1)** and **802(2)**, of compressed data memory **104**. In other words, the LDR unit **902** retrieves the compressed data from memory locations **802(0)** through **802(3)**, inclusive. LDR unit **902** then provides at least the second field **604** of each of locators **600(2)** and **600(5)**, and the compressed data from memory locations **802(0)**-**802(3)** to data trimmer **904**. Data trimmer **904** utilizes the bit offset in the second field **604** of locator **600(2)** to remove the first 37 bits of compressed data stored in memory location **802(0)**. Data trimmer **904** then utilizes the bit offset in the second field **604** of locator **600(5)** to also remove the fourth through the last bits of compressed data retrieved from memory location **802(3)**, because those bits are associated with the fifth block **202(5)** and not the fourth block **202(4)**. The resulting compressed data from memory locations **802(0)**-**802(3)** corresponds to the compressed data segments **804(2)**-**804(4)** associated with blocks **202(2)** through **202(4)**. Data trimmer **904** then provides this series of compressed data segments **804(2)**-**804(4)** to decoder **110** for decoding via data path **134**.

In a third example, RAC **114** receives a request for the last block **202(14400)** of image **200**. Upon receiving the request, LDR unit **902** retrieves locator **600(14400)** and end locator **700** from locator buffer **112** via data path **132**. Based on the memory addresses identified in first field **602** of locator **600(14400)** and the first field **702** of end locator **700**, LDR unit **902** retrieves the 64 bits of compressed data stored in memory location **802(7192)** and the 64 bits of compressed data stored in memory location **802(7193)**. LDR unit **902** then provides at least the second field **604** of locator **600(14400)** and the second field **704** of end locator **700**, and the compressed data from memory locations **802(7192)** and **802(7193)**, to data trimmer **904**. Data trimmer **904** utilizes the bit offset in the second field **604** of locator **600(14400)** to remove the first 17 bits of compressed data stored in memory location **802(7192)**, which are associated with the block **202(14399)** and not block **202(14400)**. Data trimmer **904** then utilizes the value in the second field **704** of end locator **700** to also remove the portion of the compressed data retrieved from memory location **802(7193)** that is not part of the compressed data for the last block **202(14400)**. Specifically, the 29^{th} through last bits of compressed data stored in memory location **802(7193)** are removed. The resulting compressed data from memory locations **802(7192)**-**802(7193)** corresponds to compressed data segment **804(14400)** associated with the last block **202(14400)**. RAC **114** then provides compressed data segment **804(14400)** to decoder **110** via data path **134**.

FIG. **10** is a block diagram showing decoder **110** in greater detail, according to one embodiment of the present invention. As shown in FIG. **10**, decoder **110** includes an entropy decoder **1002**, a run-length decoder **1004**, an inverse zig-zag unit **1006**, an inverse quantization unit **1008**, and an inverse DCT unit **1010**.

Compressed data segments **804(1)**-**804(*n*)** associated with blocks **202(1)**-**202(*n*)** of image **200** are provided to decoder **110** from RAC **114** via data path **134** and directly from compressed data memory **104** via data path **128** to be decoded into blocks of decoded image data. Data paths **128** and **134** converge into data path **1012**, whereby compressed data segments are provided to entropy decoder **1002** as an entropy-encoded data (EED) stream. In the present embodiment, entropy decoder **1002** decodes only one EED stream at a time. If the compressed data for an entire image **200** is to be decoded, it is efficient to provide the compressed data segments **804(1)**-**804(*n*)** directly from compressed data memory **104**. Alternatively, one or more randomly-accessed compressed data segment(s) **804(1)**-**804(*n*)** are provided to decoder **110** by RAC **114**, as described previously. Decoder **110** decodes each compressed data segment **804(1)**-**804(*n*)** according the following process.

Entropy decoder **1002** receives a compressed data segment **804** associated a block **202** via data path **1012** and performs an inverse entropy process on the compressed data segment **804** to produce RLE data associated with the block **202**. Entropy decoder **1002** employs default entropy data **1014** during entropy decoding. The default entropy data **1014** is the same as default entropy data **324** used by ELU **310** during the encoding process. Because the entropy decoder **1002** can access default entropy data **1014**, entropy decoder **1002** does not parse a data header in the compressed data stream to obtain the entropy data used during the decoding process.

Once entropy decoder **1002** has decoded the compressed data segment **804** into RLE data associated with the block **202**, entropy decoder **1002** provides the RLE data to run-length decoder **1004**. Run-length decoder **1004** decodes the RLE data into a plurality of quantized coefficients associated with the block **202**, and provides the plurality of quantized coefficients to inverse zig-zag unit **1006** via data path **1018**.

Inverse zig-zag unit **1006** receives the plurality of quantized coefficients and performs an inverse zig-zag process on the plurality of quantized coefficients to generate an 8-by-8 block of quantized coefficients. Inverse zig-zag unit **1006** then provides the block of quantized coefficients to inverse quantization unit **1008** via data path **1020**.

Inverse quantization unit **1008** receives the block of quantized coefficients and dequantizes the block into an 8-by-8 block **402** of absolute DCT coefficients using the default quantization data **1022**. The default quantization data **1022** is the same as the default quantization data **316** used by encoder **106** during the encoding process. Because inverse quantization unit **1008** can access default quantization data **1022**, inverse quantization unit **1008** advantageously does not have to parse a data header in the compressed data stream to obtain the quantization data used during the dequantization process. Following dequantization, inverse quantization unit **1008** provides the block of absolute DCT coefficients associated with the block **202** to inverse DCT unit **1010** via data path **1024**.

Inverse DCT unit **1010** receives the block of absolute DCT coefficients and performs an inverse DCT on the block of absolute DCT coefficients to produce an 8-by-8 block of decoded pixel data. Because the DCT coefficients provided by inverse quantization unit **1022** are all absolute values, the inverse DCT process is very simple compared to the prior art. For example, the relative inverse DCT process used in the prior art involves adding a relative DC coefficient of the current block to a DC coefficient value obtained from a previous block of DCT coefficients. In contrast, the inverse DCT unit **1010** of the present invention receives an absolute DC coefficient value from the inverse quantization unit **1008** and, therefore, does not have to undertake an addition process like the prior art.

Once the inverse DCT process is completed, inverse DCT unit **1010** outputs an 8-by-8 block of decoded image data decompressed from the associated compressed data segment **804**. The decoded block of image data can then be used as desired by host device **100**.

Like encoder **106**, decoder **110** is not constrained by the JPEG encoding standard and associated file formats. Advantageously, decoder **110** has access to default entropy data **1014** and default quantization data **1022** such that decoder **110** does not have to parse a header to obtain configuration information prior to decoding compressed data segments. This feature in turn provides the advantage that compressed data for an image (e.g., a frame of video) can be stored in compressed data memory **104** without the header, thereby improving data compression. Improving the compression in this way also compensates for encoding the absolute DC coefficients during the DCT process in encoder **106**.

Particular embodiments of the invention have now been described in detail. However, it should be understood that various modifications to the invention are possible and within the scope of the invention, especially in view of the concepts and principles described above.

As one example, the functions of RAC **114** can be moved within decoder **110**. For example, the locator and compressed data segment retrieval and/or compressed data trimming functions of RAC **114** can be incorporated into decoder **110** in or prior to entropy decoder **1002**. Similarly, it may also be beneficial to incorporate locator buffer **112** into a component of decoder **110** or some other component shown in FIG. **1**.

The invention can also be modified to use headers to pass configuration information (e.g., entropy tables and quantization tables, etc.) between the encoder and decoder for each frame. Additionally, a header can be used to maintain compatibility with a particular compression standard (e.g., JPEG). However, storing the header in the compressed data memory reduces the amount of data compression, and the decoder **110** would have to be modified to parse the header. The locators **600** might also have to be adjusted when they are generated to compensate for the space occupied by the header in the compressed data memory **104**.

It should also be noted that the locators described herein can also be modified according to the application. As one example, each compressed data segment **804(1)-804(***n***)** could be allocated one or more predetermined memory location(s) **802** in the compressed data memory **104**, and each locator **600(1)-600(***n***)** could be a memory pointer pointing to that predetermined location. As another example, each locator might only indicate a size of the associated compressed data segment. RAC **114** could then be modified to use these segment sizes to locate particular compressed data segments **804(1)-804(***n***)** in compressed data memory **104** in real time, for example, by summing the sizes defined in all prior locators **600** in the frame and dividing by the width of memory **104** to obtain a quotient and remainder, which could be used as described above. These and other modifications are possible.

As still another example, compressed data memory **104** and locator buffer **112** can be modified to store compressed data segments **804(1)-804(***n***)** and locators **600(1)-600(***n***)** for multiple images/frames **200**.

FIG. **11** is a block diagram of a computer system **1100** showing the encoder and/or the decoder of the present invention implemented by software, e.g., by code embodied in an electronically-readable storage medium. Computer system **1100** includes one or more processing unit(s) (CPU) **1102**, non-volatile memory **1104**, a user I/O controller **1106**, a network interface **1108**, and a working memory **1110**, all intercommunicating via a system bus **1112**. CPU(s) **1102** execute(s) data and code contained in working memory **1110** to cause computer system **1100** to carry out its intended functions (e.g. image processing, video playback, etc.). Non-volatile memory **1104** (e.g. read-only memory, one or more hard disk drives, flash memory, etc.) provides storage for data and code (e.g., boot code, encoder and decoder programs, random access controller programs, compressed image files, etc.) that are retained even when computer system **1100** is powered down. User I/O controller **1106** manages connections for user interface devices (not shown), for example a keyboard, mouse, monitor, printer, camera, and other such devices that facilitate interaction and communication between computer system **1100** and a user. Network interface **1108** (e.g. an Ethernet adapter card) transmits data packets onto and receives data packets from an internetwork (e.g., the Internet), such that a user can send and receive data (e.g., image data) via the internetwork. System bus **1112** facilitates intercommunication between the various components of computer system **1100**.

Working memory **1110** (e.g. random access memory) provides dynamic memory to computer system **1100**, and includes executable code (e.g. an operating system **1114**, etc.), which is loaded into working memory **1110** during system start-up. Operating system **1114** facilitates control and execution of all other modules loaded into working memory **1110**. Working memory **1110** also includes media programming **1116** (e.g., an image viewer, movie player, etc.). Encoder routines **1118** represent routines that perform any and all of the functionality of encoder **106** described previously herein. Encoder routines **1118** generate locators **600(1)-600(***n***)** and store those locators **600(1)-600(***n***)** in a locator buffer **1120**, which is also defined in working memory **1110**. Working memory **1110** also includes decoder routines **1122** that can perform any and all of the functionality of decoder **110** described herein. Working memory **1110** also includes a random access controller module **1124**, which provides any and all of the functions of RAC **114** shown in FIGS. **1** and **8**. Compressed data segments **804(1)-804(***n***)** generated by encoder routines **1118** are stored in compressed data buffer **1126** defined in working memory **1110**, and/or it can be stored in non-volatile memory **1104**. Optionally, the locators **600(1)-600(***n***)** stored in buffer **1120** can also be stored in non-volatile memory **1104** (e.g., as a locator file) for later retrieval.

Each of the foregoing programs and buffers can be initialized in and/or loaded into working memory **1110** from non-volatile memory **1104**. Optionally, the foregoing programs and buffers can be loaded into working memory **1110** from alternate mass data storage devices including, but not limited to, a CD-ROM, DVD-ROM, flash drive, etc. Additionally, some or all of the programs described can be loaded into working memory **1110** as needed.

The methods of the present invention will now be described with reference to FIGS. **12-15**. For the sake of clear explanation, these methods might be described with reference to particular elements of the previously-described embodiments that perform particular functions. However, it should be noted that other elements, whether explicitly described herein or created in view of the present disclosure, could be substituted for those cited without departing from the scope of the present invention. Therefore, it should be understood that the methods of the present invention are not limited to any particular element(s) that perform(s) any particular function(s). Further, some steps of the methods presented need not necessarily occur in the order shown. For example, in some cases two or more method steps may occur simultaneously. These and other variations of the methods disclosed herein will be readily apparent, especially in view of the description of the present invention provided previously herein, and are considered to be within the full scope of the invention.

FIG. **12** is a flowchart summarizing a method **1200** of facilitating random access to segments of compressed data stored in a compressed data memory, according to the present invention. In a first step **1202**, a series of data segments (e.g., blocks **202**(**1**)-**202**(*n*) of image **200**) are received via a data input **116**. In a second step **1204**, encoder **106** encodes the series of data segments into a series of compressed data segments **804**(**1**)-**804**(*n*), where each of the compressed data segments **804**(**1**)-**804**(*n*) has a variable segment size. Then, in a third step **1206**, the series of compressed data segments **804**(**1**)-**804**(*n*) are stored in the compressed data memory **104**. In a fourth step, **1208**, a locator generator **108** generates a locator **600** for each of the compressed data segments **804**(**1**)-**804**(*n*) in the series, where the locators **600**(**1**)-**600**(*n*) are indicative of the locations of the associated compressed data segments **804**(**1**)-**804**(*n*) in the compressed data memory **104**.

FIG. **13** is a flowchart summarizing a particular method of performing the second step **1204** (encode the series of data segments) of method **1200** according to the present invention. The method shown in FIG. **13** is performed for each data segment in the series of data segments. According to this method, the series of data segments comprise blocks **202**(**1**)-**202**(*n*) of pixel data of an image **200**.

In a first step **1302**, a discrete cosine transform (DCT) is performed on one of the blocks **202**(**1**)-**202**(*n*) of pixel data to produce a block **402** of DCT coefficients, where the DCT coefficients are absolute values (i.e., is not defined relative to DCT coefficients in another block). Then, in a second step **1304**, the block **402** of absolute DCT coefficients is quantized using quantization data **316** to produce a block of quantized coefficients. Next, in a third step **1306**, the block of quantized coefficients is zig-zag encoded to produce a sequence of quantized coefficients and, in a fourth step **1308**, the sequence of quantized coefficients is run-length encoded to produce run-length-encoded (RLE) data. Then, in a fifth step **1310**, the RLE data is entropy encoded using entropy data **324** to produce one of the series of compressed data segments **804**(**1**)-**804**(*n*).

FIG. **14** is flowchart summarizing a particular method of performing the fourth step **1208** (generate locator) of the method **1200** according to the present invention. The method shown in FIG. **14** is performed for each locator **600** of the plurality of locators **600**(**1**)-**600**(*n*) that is generated. Recall that each locator **600**(**1**)-**600**(*n*) is associated with one of the series of compressed data segments **804**(**1**)-**804**(*n*).

In a first step **1402**, a sum of the sizes of each of the compressed data segments **804** in the series of compressed data segments **804**(**1**)-**804**(*n*) that were previously stored in the compressed data memory **104** is calculated. Then, in a second step **1404**, this sum is divided by a value equal to the width (e.g., 64 bits) of each of the memory locations **802**(**0**)-**802**(*x*) of compressed data memory **104** to obtain a quotient and a remainder. Then, in a third step **1406**, the quotient is converted to a memory address identifying the memory location **802** of memory locations **802**(**0**)-**802**(*x*) where the compressed data segment **804** associated with the locator **600** will be stored. Then, in a fourth step **1408**, the locator **600** for the associated compressed data segment **804** is created with a first field **602** containing the memory address and a second field **602** containing the remainder.

FIG. **15** is a flowchart summarizing a method **1500** of randomly accessing a compressed data segment **804** of the series of compressed data segments **804**(**1**)-**804**(*n*) from a compressed data memory **104**, according to the present invention. In a first step **1502**, a request for at least one compressed data segment **804** corresponding to at least one data segment (e.g., at least one of blocks **202**(**1**)-**202**(*n*) of image **200**) is received via data request input **120**. The requested compressed data segment **804** is one of a series of variable-size compressed data segments **804**(**1**)-**804**(*n*) stored in compressed data memory **104**. Then, in a second step **1504**, at least one locator **600** associated with the requested compressed data segment **804** is retrieved from locator buffer **112**. Next, in a third step **1506**, the retrieved locator **600** is used to locate the requested compressed data segment **804** among the series of compressed data segments **804**(**1**)-**804**(*n*) in the compressed data memory **104**. Then, in a fourth step **1508**, the requested compressed data segment **804** is retrieved from compressed data memory **104** by RAC **114** and provided to decoder **110**. Following, in a fifth step **1510**, the requested compressed data segment **804** is decoded by decoder **110** and a decoded data segment is provided on decoded data output **118**.

The description of particular embodiments of the present invention is now complete. Many of the described features may be substituted, altered or omitted without departing from the scope of the invention. For example, alternative locators (e.g., memory pointers, segment sizes, etc.), may be substituted for the locators described herein. As another example, frame headers can be employed to facilitate changing the data used during encoding and decoding (e.g., quantization data and entropy data) each frame. These and other deviations from the particular embodiments shown will be apparent to those skilled in the art, particularly in view of the foregoing disclosure.

We claim:

1. A method facilitating random access to segments of compressed data stored in memory, said method comprising:

receiving a series of data segments;

encoding said series of data segments into a series of compressed data segments, each of said compressed data segments having a variable segment size;

storing said series of compressed data segments in a compressed data memory;

determining the size of each of said compressed data segments; and

generating a locator for each of said compressed data segments; and wherein

said locator identifies a memory location of said compressed data memory storing at least part of an associated compressed data segment;

said locator includes a memory address and an offset, said memory address identifying said memory location from a plurality of memory locations of said compressed data memory, and said offset being indicative of the position of a first bit of said associated compressed data segment within said memory location; and

said step of generating said locator of said associated compressed data segment includes

calculating a sum of the sizes of each of said compressed data segments in said series stored prior to said associated compressed data segment,

dividing said sum by a value equal to the width of each of said plurality of memory locations of said compressed data memory to obtain a quotient and a remainder,

converting said quotient to said memory address, and

setting said offset equal to said remainder.

2. The method of claim **1**, wherein:

said series of data segments comprises a series of blocks of image data;

said step of encoding includes performing a Discrete Cosine Transform (DCT) on each block of image data in said series to generate a series of blocks of DCT coefficients; and

the DCT coefficients in each said block of DCT coefficients are generated without reference to any other block of DCT coefficients in said series.

3. The method of claim 2, wherein, for each block of DCT coefficients in said series of blocks of DCT coefficients, said step of encoding further includes:

quantizing said block of DCT coefficients to produce a block of quantized coefficients;

zig-zag encoding said block of quantized coefficients to produce a sequence of quantized coefficients;

run-length encoding said sequence of quantized coefficients to produce run-length-encoded (RLE) data; and

entropy encoding said RLE data to produce one of said series of compressed data segments.

4. The method of claim 3, further comprising:

receiving a second series of data segments;

encoding said second series of data segments into a second series of compressed data segments; and wherein:

said step of quantizing said block of DCT coefficients includes using quantization data to quantize said block of DCT coefficients;

said step of entropy encoding said RLE data includes using entropy data to entropy-encode said RLE data; and

said quantization data and said entropy data does not change between said steps of encoding said series of data segments and encoding said second series of data segments.

5. The method of claim 1, wherein said series of compressed data segments is stored in said compressed data memory free of header information associated with said series of compressed data segments.

6. The method of claim 1, further comprising storing said locator for each of said compressed data segments.

7. The method of claim 6, further comprising:

receiving a request for at least one compressed data segment selected from said series of compressed data segments stored in said compressed data memory;

retrieving the locator associated with said requested compressed data segment;

using said retrieved locator to locate the beginning of said requested compressed data segment among said series of compressed data segments stored in said compressed data memory; and

retrieving said requested compressed data segment from said compressed data memory.

8. The method of claim 7, further comprising:

retrieving a second locator associated with a second compressed data segment stored in said compressed data memory; and

using said second locator to locate the end of said requested compressed data segment in said compressed data memory.

9. The method of claim 7, further comprising decoding said requested compressed data segment out of order with the rest of said series of compressed data segments.

10. The method of claim 9, wherein said step of decoding said requested compressed data segment includes:

entropy decoding said requested compressed data segment to produce run-length-encoded (RLE) data;

run-length decoding said RLE data to produce a plurality of quantized coefficients;

performing an inverse zig-zag process on said plurality of quantized coefficients to produce a block of quantized coefficients;

dequantizing said block of quantized coefficient to produce a block of absolute Discrete Cosine Transform (DCT) coefficients; and

performing an inverse DCT process on said block of absolute DCT coefficients without reference to any other block of DCT coefficients to produce a block of decoded data.

11. The method of claim 10, wherein said step of decoding said requested compressed data segment does not include parsing a header associated with said series of compressed data segments prior to decoding said requested compressed data segment.

12. The method of claim 1, wherein:

said series of data segments comprises a series of blocks of image data defining an image; and

said compressed data memory is a frame buffer for storing compressed data defining said image.

13. A system facilitating random access to segments of compressed data stored in memory, said system comprising:

a data input coupled to receive a series of data segments;

an encoder operative to encode said series of data segments into a series of compressed data segments, each of said compressed data segments having a variable segment size;

a compressed data memory coupled to receive said series of compressed data segments from said encoder and to store said series of compressed data segments; and

a locator generator operative to determine the size of each of said series of said compressed data segments and to generate a locator for each of said series of compressed data segments; and wherein

said locator identifies a memory location of said compressed data memory storing at least part of an associated compressed data segment;

said locator includes a memory address and an offset, said memory address identifying said memory location from a plurality of memory locations of said compressed data memory, and said offset being indicative of the position of a first bit of said associated compressed data segment within said memory location; and

for each of said associated compressed data segments, said locator generator is further operative to

calculate a sum of the sizes of each of said compressed data segments in said series stored prior to said associated compressed data segment,

divide said sum by a value equal to the width of each of said plurality of memory locations of said compressed data memory to obtain a quotient and a remainder,

convert said quotient to said memory address, and

set said offset equal to said remainder.

14. The system of claim 13, wherein:

said series of data segments comprises a series of blocks of image data;

said encoder is operative to perform a Discrete Cosine Transform (DCT) on each block of image data in said series to generate a series of blocks of DCT coefficients; and

the DCT coefficients in each said block of DCT coefficients are generated without reference to any other block of DCT coefficients in said series.

15. The system of claim 14, wherein, for each block of DCT coefficients in said series of blocks of DCT coefficients, said encoder is further operative to:

quantize said block of DCT coefficients to produce a block of quantized coefficients;

zig-zag encode said block of quantized coefficients into a sequence of quantized coefficients;

run-length encode said sequence of quantized coefficients to produce run-length-encoded (RLE) data; and

entropy encode said RLE data to generate one of said series of compressed data segments.

16. The system of claim **15**, wherein:

said input terminal set is further operative to receive a second series of data segments;

said encoder is further operative to

encode said second series of data segments into a second series of compressed data segments,

quantize said block of DCT coefficients using quantization data, entropy encode said RLE data using entropy data; and

said encoder is operative to encode said series of data segments and said second series of data segments using the same said quantization data and said entropy data.

17. The system of claim **13**, wherein said series of compressed data segments is stored in said compressed data memory free of header information associated with said series of compressed data segments.

18. The system of claim **13**, further comprising a locator memory operative to store said locator for each of said compressed data segments.

19. The system of claim **18**, further comprising:

a data request input operative to receive a request for at least one compressed data segment stored among said series of compressed data segments in said compressed data memory; and

a controller operative to

retrieve the locator associated with said requested compressed data segment,

use said retrieved locator to locate the beginning of said requested compressed data segment among said series of compressed data segments in said compressed data memory, and

retrieve said requested compressed data segment from said compressed data memory.

20. The system of claim **19**, wherein said controller is further operative to:

retrieve a second locator associated with a second compressed data segment stored in said compressed data memory; and

use said second locator to locate the end of said requested compressed data segment in said compressed data memory.

21. The system of claim **19**, further comprising a decoder operative to decode said requested compressed data segment out of order with the rest of said series of compressed data segments.

22. The system of claim **21**, wherein said decoder includes:

an entropy decoder operative to entropy decode said requested compressed data segment to produce run-length-encoded (RLE) data;

a run-length decoder operative to run-length decode said RLE data to produce a plurality of quantized coefficients;

an inverse zig-zag unit operative to perform an inverse zig-zag process on said plurality of quantized coefficients to produce a block of quantized coefficients;

a dequantizer operative to dequantize said block of quantized coefficient to produce a block of absolute Discrete Cosine Transform (DCT) coefficients; and

an inverse DCT unit operative to perform an inverse DCT process on said block of absolute DCT coefficients without reference to any other block of DCT coefficients.

23. The system of claim **22**, wherein said decoder is operative to decode said requested compressed data segment without parsing a header associated with the series of compressed data segments prior to decoding said requested compressed data segment.

24. The system of claim **13**, wherein:

said series of data segments comprises a series of blocks of image data defining an image; and

said compressed data memory is a frame buffer for storing compressed data defining said image.

25. A non-transitory, electronically-readable storage medium having code embodied therein for causing an electronic device to:

receive a series of data segments;

encode said series of data segments into a series of compressed data segments, each of said compressed data segments having a variable segment size;

store said series of compressed data segments in a compressed data memory;

determine the size of each of said compressed data segments; and

generate a locator for each of said compressed data segments; and wherein

said locator identifies a memory location of said compressed data memory storing at least part of an associated compressed data segment;

said locator includes a memory address and an offset, said memory address identifying said memory location from a plurality of memory locations of said compressed data memory, and said offset being indicative of the position of a first bit of said associated compressed data segment within said memory location; and

said locator for each of said compressed data segments is generated by causing said electronic device to

calculate a sum of the sizes of each of said compressed data segments in said series stored prior to said associated compressed data segment,

divide said sum by a value equal to the width of each of said plurality of memory locations of said compressed data memory to obtain a quotient and a remainder,

convert said quotient to said memory address, and

set said offset equal to said remainder.

26. The non-transitory, electronically-readable storage medium of claim **25**, wherein:

said series of data segments comprises a series of blocks of image data;

said step of encoding includes performing a Discrete Cosine Transform (DCT) on each block of image data in said series to generate a series of blocks of DCT coefficients; and

the DCT coefficients in each said block of DCT coefficients are generated without reference to any other block of DCT coefficients in said series.

27. The non-transitory, electronically-readable storage medium of claim **26**, wherein, for each block of DCT coefficients in said series of blocks of DCT coefficients, said code is further operative to cause said electronic device to:

quantize said block of DCT coefficients to produce a block of quantized coefficients;

zig-zag encode said block of quantized coefficients to produce a sequence of quantized coefficients;

run-length encode said sequence of quantized coefficients to produce run-length-encoded (RLE) data; and entropy encode said RLE data to produce one of said series of compressed data segments.

28. The non-transitory, electronically-readable storage medium of claim 27, wherein said code is further operative to cause said electronic device to:

receive a second series of data segments;

encode said second series of data segments into a second series of compressed data segments; and wherein:

use quantization data to quantize said block of DCT coefficients;

use entropy data to entropy-encode said RLE data; and wherein

said quantization data and said entropy data do not change between encoding said series of data segments and encoding said second series of data segments.

29. The non-transitory, electronically-readable storage medium of claim 25, wherein said series of compressed data segments is stored in said compressed data memory free of header information associated with said series of compressed data segments.

30. The non-transitory, electronically-readable storage medium of claim 25, wherein said code is further operative to cause said electronic device to store said locator for each of said compressed data segments.

31. The non-transitory, electronically-readable storage medium of claim 30, wherein said code is further operative to cause said electronic device to:

receive a request for at least one compressed data segment selected from said series of compressed data segments stored in said compressed data memory;

retrieve the locator associated with said requested compressed data segment;

use said retrieved locator to locate the beginning of said requested compressed data segment among said series of compressed data segments stored in said compressed data memory; and

retrieve said requested compressed data segment from said compressed data memory.

32. The non-transitory, electronically-readable storage medium of claim 31, wherein said code is further operative to cause said electronic device to:

retrieve a second locator associated with a second compressed data segment stored in said compressed data memory; and

use said second locator to locate the end of said requested compressed data segment in said compressed data memory.

33. The non-transitory, electronically-readable storage medium of claim 31, wherein said code is further operative to cause said electronic device to decode said requested compressed data segment out of order with the rest of said series of compressed data segments.

34. The non-transitory, electronically-readable storage medium of claim 33, wherein said code is further operative to cause said electronic device to:

entropy decode said requested compressed data segment to produce run-length-encoded (RLE) data;

run-length decode said RLE data to produce a plurality of quantized coefficients;

perform an inverse zig-zag process on said plurality of quantized coefficients to produce a block of quantized coefficients;

dequantize said block of quantized coefficient to produce a block of absolute Discrete Cosine Transform (DCT) coefficients; and

perform an inverse DCT process on said block of absolute DCT coefficients without reference to any other block of DCT coefficients to produce a block of decoded data.

35. The non-transitory, electronically-readable storage medium of claim 34, wherein said electronic device does not parse a header associated with said series of compressed data segments prior to decoding said requested compressed data segment.

36. The non-transitory, electronically-readable storage medium of claim 25, wherein:

said series of data segments comprises a series of blocks of image data defining an image; and

said compressed data memory is a frame buffer for storing compressed data defining said image.

37. A system facilitating random access to segments of compressed data stored in memory, said system comprising:

an input terminal set coupled to receive a series of data segments;

means for encoding said series of data segments into a series of compressed data segments, each of said data segments being encoded independently of any other of said compressed data segments, each of said compressed data segments having a variable segment size;

a compressed data memory coupled to receive and store said series of compressed data segments; and

means for locating each of said compressed data segments in said compressed data memory, said means for locating being operative to determine the size of each of said series of said compressed data segments and to generate a locator for each of said series of compressed data segments; and wherein

said locator identifies a memory location of said compressed data memory storing at least part of an associated compressed data segment;

said locator includes a memory address and an offset, said memory address identifying said memory location from a plurality of memory locations of said compressed data memory, and said offset being indicative of the position of a first bit of said associated compressed data segment within said memory location; and

for each of said associated compressed data segments, said means for locating each of said compressed data segments is further operative to

calculate a sum of the sizes of each of said compressed data segments in said series stored prior to said associated compressed data segment,

divide said sum by a value equal to the width of each of said plurality of memory locations of said compressed data memory to obtain a quotient and a remainder,

convert said quotient to said memory address, and

set said offset equal to said remainder.

38. A method for randomly accessing a segment of compressed data from memory, said method comprising:

receiving a request for a compressed data segment selected from a series of compressed data segments stored in a compressed data memory, each of said compressed data segments having a variable segment size;

retrieving a locator defining a size;

using said retrieved locator to locate said requested compressed data segment within said series of compressed data segments in said compressed data memory; and

retrieving said requested compressed data segment from said compressed data memory; and wherein said step of using said retrieved locator to locate said requested compressed data segment includes

determining a sum of the sizes of each of said compressed data segments in said series stored prior to said requested compressed data segment,

dividing said sum by a value equal to a width of each of a plurality of memory locations of said compressed data memory to obtain a quotient and a remainder,

converting said quotient to a memory address, and

setting an offset equal to said remainder;

said memory address identifies a memory location of said compressed data memory storing at least part of said requested compressed data segment; and

said offset indicates the position of a first bit of said requested compressed data segment within said memory location.

39. A system for randomly accessing a segment of compressed data from memory, said system comprising:

a data request input operative to receive a request for at least one compressed data segment selected from a series of compressed data segments stored in a compressed data memory, each of said compressed data segments having a variable segment size; and

a controller operative to

retrieve a locator including a size,

use said retrieved locator to locate said requested compressed data segment within said series of compressed data segments in said compressed data memory, and

retrieve said requested compressed data segment from said compressed data memory; and wherein

to use said retrieved locator to locate said requested compressed data segment, said controller is further operative to

determine a sum of the sizes of each of said compressed data segments in said series stored prior to said requested compressed data segment,

divide said sum by a value equal to a width of each of a plurality of memory locations of said compressed data memory to obtain a quotient and a remainder,

convert said quotient to a memory address, and

set an offset equal to said remainder;

said memory address identifies a memory location of said compressed data memory storing at least part of said requested compressed data segment; and

said offset indicates the position of a first bit of said requested compressed data segment within said memory location.

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